VOLUME 7 NUMBER 2

APRIL 1917

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Phytopathology

Official Organ of the

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PUBLISHED BIMONTHLY FOR THE SOCIETY

OFFICE OF PUBLICATION
2419-21 Greenmount Ave., Baltimore, Md.

Entered as second-class matter May 16, 1913, at the post office at Baltimore, Maryland, under the Act of March 3, 1879

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PHYTOPATHOLOGY

VOLUME VII NUMBER 2

APRIL, 1917

THE PERFECT STAGE OF GLŒOSPORIUM VENETUM

WALTER H. BURKHOLDER

WITH THREE FIGURES IN THE TEXT

During the early summer of 1914 while studying the anthracnose disease of the raspberry at Brant, New York, a peculiar ascomycete was observed by the writer. The fungus although not of general occurrence was found only in the anthracnose lesions (fig. 1), and arose from the stroma of the pathogene *Glœosporium venetum* Speg. This led to the belief that there was a possible connection between the two fungous forms and a number of inoculation experiments were conducted in order to verify this assumption.

It was difficult to obtain ascospores for making inoculations owing to the scarcity of the ascocarps. Furthermore the ascospores were borne in the same lesion with the conidia of *Glœosporium venetum* and a separation of the two types of spores was practically impossible. It was finally decided to use spores from a culture of the fungus developed from a single ascospore.

Several attempts were made to isolate the fungus. The poured plate method first employed was discarded later on account of the difficulty in obtaining ascospores sufficiently removed from the conidia, the latter usually being in great abundance. A second method and similar to one used by Barber[1] was also tried. This consisted in crushing the ascocarps in a drop of sterilized water on a sterilized slide. A glass tube with a bore of about 3 mm. was drawn to a capillary tip at one end; to the opposite end was fastened a piece of rubber tubing about 40 cm. in length. The free end of the rubber tube was placed in the mouth and by manipulating the glass point with the hand, spores could be drawn into the bore of the tube. The great difficulty in using this method with the fungus under consideration was the fact that the ascospores were very gelatinous and had a tendency to adhere to the glass slides, refusing to enter the

[1] Barber, M. A. On heredity in certain microorganisms. Kansas Sci. Bul. 4: 3-48. 1907.

bore of the tube. Single asci, however, could be picked up in this manner and cultures of the fungus were obtained.

A third method and the most satisfactory one employed was made use of after it was observed that the ascospores were forcibly ejected from the asci. The culture used in the following experiments was isolated on August 14, 1914, and in the following manner: A sterilized petri dish containing a thin layer of nutrient agar was inverted over a small piece of raspberry cane which contained the fruiting bodies of the ascomycete. The cane was then moistened and the petri dish allowed to remain in place for about fifteen hours, during which time a few spores were ejected

FIG. 1. ANTHRACNOSE LESIONS ON CANES OF THE BLACK RASPBERRY

from the asci and lodged upon the agar surface above. A single ascospore was then located by means of a low magnifying microscope and the position of the spore marked on the lower side of the petri dish. The germination and development of the spore was observed and when sufficient growth had taken place the fungus was transferred to a test-tube. Growth of the ascomycete in culture is identical with that of *G. venetum*. On potato agar the fungus develops a wrinkled sclerotium-like mass with minute filamentous hyphae radiating in all directions. The colony is at first circular, growing very slowly and varies with age from a pale vinaceous pink to a maroon color. The cells of the mycelium composing the fungous mass vary greatly in size. They are globose and filled with oil

globules and pigments which give color to the fungus. Only on rare occasions and on media containing a small percentage of agar do filamentous hyphae extend for any distance from the sclerotia-like formations. This growth on artificial media although identical with that of *G. venetum* is decidedly different from that of any species of Glœosporium which has a perfect stage belonging to the genus Glomerella.

As the writer has continually found to be the case with cultures of *G. venetum*, difficulty was encountered in finding conditions favorable for the sporulation of the fungus. It was finally observed, however, that a sudden change in the humidity of the culture tube caused a production of conidia which were obtainable in sufficient numbers for use. In order to effect this change the fungus was grown on three-per-cent potato agar until large sclerotia-like masses were formed. These masses were transferred to sterilized bean pods in tubes which contained several centimeters of water. The cultures were then incubated at a temperature of 24°C. and at the end of three days numerous conidia were produced which were identical with the conidia produced in culture by *G. venetum*. It was also observed that this sporulation was not continuous, but ceased after the first production of spores. Furthermore, a culture of the fungus subjected from the beginning to a moist condition produced no spores or at least, but relatively few. This apparently indicates that the sudden increase in humidity acts as a stimulus to spore formation.

By dropping these fungous masses bearing conidia into a small amount of water the spores readily fall off and can be sprayed over the infection court. The germination of these conidia is fairly rapid, but the percentage of germination is low. In most cases not more than five or ten per cent of the spores germinate.

INOCULATION EXPERIMENTS

Early in the winter of 1914 a number of roots of the Columbian variety of the raspberry were obtained and planted in the greenhouse. Owing to the earliness of the dormant period and to the unfavorable conditions arising within the greenhouse, the plants grew slowly, and gave a very stunted growth. All inoculation experiments with these plants gave negative results. The anthracnose lesions appear only on tender succulent canes and apparently the canes which had developed slowly on the greenhouse plants were too hard for the fungus to infect.

Later, about the first of March, 1915, a few raspberry plants of a red variety were secured which were tender and growing rapidly. On March 4, two canes were sprayed with a suspension of conidia from a culture of the fungus developed from a single ascospore and the canes were covered

with bell-glasses lined with moist filter paper. These glasses were plugged at the top with cotton and allowed to remain over the canes for two days before removing, while two other canes in the same bed remained untreated. On March 20, small purple spots had appeared on one of the canes. These infections grew slowly, much slower than an anthracnose lesion develops under field conditions, but spots typical of those caused by *Glœosporium venetum* were produced. Miscroscopical examination of the spots showed conidia of *G. venetum*.

Again on April 15, four very tender canes of a black-cap variety of raspberry were sprayed with a suspension of conidia as above. Bell glasses were placed over the plants as in the previous experiments and one check plant was used. A sample of the conidia used was placed in a drop of water on a slide, and about eight per cent of the spores germinated. After one week, April 21, a number of small purple spots had appeared on the four canes, and these later developed into typical anthracnose lesions. The check plant remained healthy.

THE DEVELOPMENT OF THE ASCIGEROUS STAGE

From the positive results of the inoculation experiments and also from the examination of the fungus in culture it is evident that the ascomycete under consideration is the perfect stage of *Glœosporium venetum*. The systematic position of the fungus, however, is rather difficult to determine. Its morphology is entirely different from the perfect stage of any species of Glœosporium previously described. This, however, is not surprising as *G. venetum* has always been considered distinct from the other species of that genus.

The ascigerous stage of the fungus was first observed on the hybrid raspberry commonly known as *Rubus neglectus*. Later it was collected in various parts of New York State on the black raspberry (*Rubus occidentalis*) and the American red raspberry (*Rubus idæus* var. *aculeatissimus*). Rees[2] also reports having found it in Washington on the blackberry (*Rubus* sp.).

During the summer following the discovery of the ascigerous stage close observation was kept of the fungus on the young canes to determine when the ascocarps first began to develop. This proved to be about the middle of August. At this time the fruiting bodies which greatly resemble those in the family Myriangiaceæ appear as minute spots, deep brown to black, singly or in groups scattered over the buff-colored and sunken portion of the anthracnose lesion. These spots are barely visible to the eye

[2] Rees, H. L. Experimental spraying for blackberry anthracnose in 1915. Western Washington Exp. Sta. Mo. Bul. 3[8]: 1-10. 1915.

and only so on account of the contrast in color with the surrounding tissue. After passing the winter the entire lesion assumes a dark brown color and then the pustules are observed with great difficulty even with a hand lens.

A careful examination of the diseased area upon which the asco arps are found proves it to be a typical anthracnose lesion. The buff-colored portion is fungous tissue, more or less plectenchymatous in structure. It is composed of very small hyphae which are difficult to distinguish unless carefully stained and it is the same tissue from which arise the conidiophores of the Glœosporium stage. The ascocarps arise from the stroma and are pulvinate structures usually circular in outline, but they frequently coalesce, forming spots of various shapes. They are approximately 0.07 by 0.07 to 0.37 mm. in diameter. The tissue of the ascocarp is more or less pseudoparenchymatous with larger and thinner-walled cells than those of the stromataceous tissue (fig. 2). The outer layer of the ascocarp is composed of thick-walled brown cells which form a shield-shaped structure less perfect, however, than those observed in the family Microtheriaceæ. When the fruiting body is mature the cells of this outer layer split apart in a stellate manner and crumble away. Within the shield the ascocarps are hyaline and contain the asci which are scattered irregularly through the fungous tissue. There is no differentiated cavity for the asci.

The asci were first observed in the immature condition at which time they appeared as globose bodies containing a homogenous mass of protoplasm, and greatly resembling thick-walled oogonia. These asci may lie in contact with each other but frequently they are separated by the fungous tissue. The mature ascus is thick-walled and measures 24 to 30μ in diameter. In a few cases the ascus has appeared to be slightly stalked and attached to the base of the cavity in which it is borne.

In the autumn or more often in the spring the asci mature and the homogenous mass of protoplasm gives place to eight four-celled ascospores. These spores which are borne parallel to each other in the ascus, are hyaline with gelatinous walls, and constricted at the septa. The basal cell is somewhat more obtuse than the apical cell. The mature ascospore measures 18 to 21μ in length by 6.5 to 8μ in diameter.

In the formation of these spores the middle septum is laid down much earlier than the other two, and for this reason it is not uncommon to find two-celled spores. With the division of these cells giving rise to the four-celled condition, the constrictions are not so great as at the first septum. Occasionally one of the cells fails to divide and an ascospore of three cells is formed. During the formation of the spore the disintegration of the fungous tissue about the asci takes place and with the rupturing of the outer layer of the ascocarp the asci are exposed. Frequently the

asci lying in this exposed condition surrounded by the remainder of the ascocarp give the appearance of a true discomycete. This, however, is due to the persistency of the outer cells of the shield-like layer which

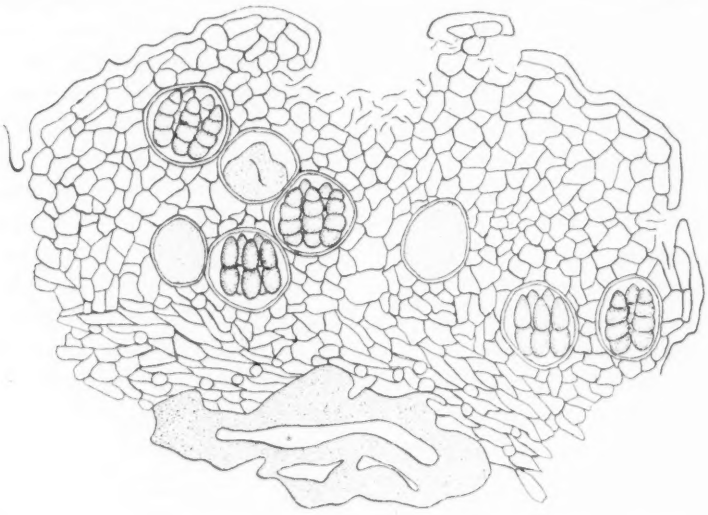

FIG. 2. CROSS-SECTION OF ASCOCARP OF PLECTODISCELLA VENETA
Various stages in the development of the asci are shown

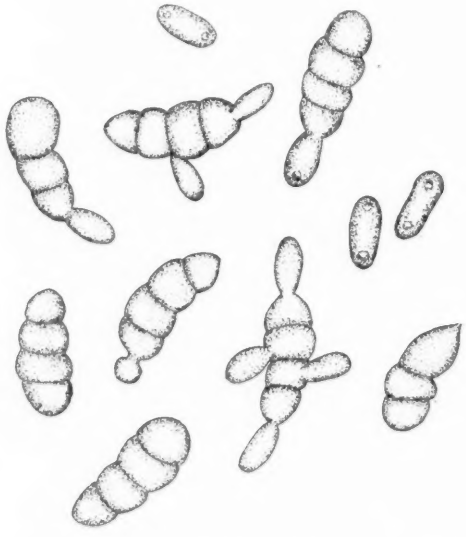

FIG. 3. ASCOSPORES OF PLECTODISCELLA VENETA AND THEIR METHOD OF GERMINATION

covers the immature ascocarps. With the presence of sufficient moisture the exposed asci elongate approximately three times their usual length. This process is very rapid and may be observed under a microscope when a fragment of tissue containing asci is placed in a drop of water. The lower portion of the ascus remains fastened in the cavity in which it was borne, giving a conical shape to the body which raises itself above the surrounding tissue. The spores gather at the tip of the ascus and from there are ejected into the air. They have been caught above the lesions at a distance of one centimeter.

In a single ascocarp all the asci are never in the same state of maturity and the ascocarps also seem to vary in this respect. Mature ascospores were first observed about the first of June while immature spores were present in August.

GERMINATION OF SPORES

When placed in tap, rain or distilled water, or on nutrient agar, the mature ascospores germinate readily (fig. 3). They swell somewhat and within less than two hours a short sterigma is produced from one or each of the cells. A sprout conidium is formed which is oblong to elliptical and identical with the conidia of the fungus. When fully mature the sprout conidia drop from the sterigmata but do not germinate immediately. After a short period of rest, twelve to twenty-four hours, a germ-tube is sent forth and mycelium is formed. When an ascus is placed in a drop of water or on agar the spores within will germinate by sending the sterigmata through the wall of the ascus and produce the sprout conidia on the outside. These, in turn, germinate. After the production of the secondary spores, however, the ascospores shrivel and disintegrate.

SYSTEMATIC POSITION

The morphology of the fungus of the raspberry anthracnose, especially the character of the asci scattered irregularly through a pseudoparenchyma is similar to that of the old family Myriangiaceæ. In a revision of this family some years ago by von Höhnel[3] but five genera out of twenty-three were retained, and since then but one new genus, Ascostralum Sydow[4] has been added. The perfect stage of *Glœosporium venetum*, however, does not appear to fall in any of these genera, nor in any of the genera of closely

[3] Höhnel, F. von. Fragments zur mycologie VI. Mitt. 244. Sitzungsber. M-N Classe, k. k. Akad. Wiss. Wien. **118**: 349-376. 1909.

[4] Sydow, H. von and Sydow P. von. Beschreibungen neuen südafrikanischen Pilze. Ann. Myc. **10**: 41-42. 1912.

related families. More recently Woronichin[5] described a new genus, Plectodiscella, based on a single species which he found occurring on the leaves of the apple and pear. This genus is closely related to Elsinœ of Raciborski[6] but differs mainly in that the stroma is not borne beneath the epidermis. *Plectodiscella Piri*, the representative of the genus, is so similar in morphology to the ascigerous stage of *Glœosporium venetum* Speg. that apparently there is a distinct relation between the two. A brief description of Woronichin's species is here set forth: A more or less imperfect stroma is formed in the epidermal and sub-epidermal cells of the leaf, which is at first sub-cuticular. From this arises a fungous tissue in which are borne irregular globose asci, each containing eight four-celled ascopores. In some instances the asci are separated by the fungous tissue and in others they lie in contact with each other. Woronichin is uncertain as to the nature of this tissue between the asci. He says, "Was für Elemente die zwischen den Ascen befindlichen Zwischenräume ausfüllen, gelang es nicht genau aufzuklären." He does not consider, however, that it is cellular. This is also the first impression received in regard to the raspberry fungus, due to the fact that the cells are minute and disintegrate very early. The cellular structure of the fungus on raspberry was determined only on young material and then after it was fixed and stained. In *Plectodiscella Piri* a shield-like arrangement composed of one layer of dark cells covers each ascocarp and later breaks apart in order that the asci may be exposed. In the perfect stage of *Glœosporium venetum* this is present but is clearly seen only in the immature stages before rupturing occurs. Woronichin does not refer to an imperfect stage for his fungus.

Plectodiscella Piri is considered to be far enough removed from the Myriangiaceæ or any of its closely related families to be placed in a new family. This, Woronichin describes as Plectodiscelleæ and states that it occupies a systematic position somewhere between the Plectascales and the true Discomycetes. Here he places his fungus *P. Piri* but gives no exact characters for his genus. Only the family and species are described.

Taking all characters into consideration, the perfect stage of *Glœosporium venetum* Speg. appears to belong to this genus and therefore the following name is proposed:

[5] Woronichin, N. M. Plectodiscella Piri, der Vertreter einer neuen ascomyceten Gruppe. Mycol. Centralb. **4**: 225-233. 1914.

[6] Raciborski, M. Elsinœ Rac. nov. gen. Parasitische Algen und Pilze Java's **1**: 15-16. 1900.

Plectodiscella veneta sp. nov.

Stromatibus solitariis vel gregariis, pulvinatis, epidermide fusca discoida, mox dehiscente, intus contextu hyalino, pseudoparenchymatico vel indistincto, plerumque pluriloculigeris, loculis monascis, irregulariter sparsis; ascis globosis, 8 sporis, 24-30μ; sporidiis ovoideo-ellipsoideis, saepe flexis, hyalinio, 3-septatis, constrictis, cellula basilare obtusa, 18-21 x 6.5 x 8μ.

Hab. In ramis caulibusque vivis Rubi occidentalis, R. idaei var. aculeatissimi et R. neglecti. New York, America boreale. Status conidiophorus est Glœosporium venetum Speg.

CORNELL UNIVERSITY
ITHACA, NEW YORK

PUCCINIA SUBNITENS AND ITS AECIAL HOSTS

ELLSWORTH BETHEL

Puccinia subnitens Diet. is a common rust on *Distichlis spicata* from the Atlantic to the Pacific coast. The telial host is especially abundant in the alkaline soils of the desert regions of the western United States. Prior to 1904, *Chenopodium album* was the only known aecial host of this rust. In the summer of 1904, Rev. J. M. Bates, from field observations in Nebraska, concluded that aecia on species of Cleome, Sophia, Lepidium, Erysimum, and Salsola were related to *Puccinia subnitens*. These suggestions were communicated to Dr. J. C. Arthur, who later in the summer succeeded in growing the teliospores on these hosts, thus confirming the deductions made by Bates. Dr. Arthur, in giving the results of these cultures, remarks (Jour. Myc. **11**: 50-67), "We have here a demonstration of the remarkable fact, not known for any other species of rust, that *Puccinia subnitens* has aecia growing with equal vigor on three families of plants." Later, Arthur grew it on *Capsella* (Bursa) sp., *Atriplex hastata*, and doubtfully on *Sarcobatus* sp. He has grown this species on nine or ten genera in three families.

For ten years or more, the writer has observed the aecia of this rust abundant in Colorado on species of Polygonum, Chenopodium, Lepidium, Capsella, Cleome, Salsola, and Abronia, and in 1912 made successful cultures on all of these genera except Abronia. During the past summer, aecia which seemed unmistakably related to *Puccinia subnitens* were found on plants of several other genera, and cultures were made to determine the correctness of these observations. Likewise all previous cultures were repeated with the result that the aecia were produced on 22 species in 6 families, and 15 genera. The following is a list of successful cultures.

1. POLYGONACEÆ: *Polygonum aviculare* L., *P. erectum* L., *P. ramosissimum* Michx.

2. CHENOPODIACEÆ: *Salsola pestifer* A. Nels., *Chenopodium album* L., *C. glaucum* L., *C. lanceolatum* Muhl., *C. pagonum* Reich., *Monolepis nuttalliana* (R. & S.) Greene, *Kochia scoparia* (L.) Roth.

3. AMARANTHACEÆ: *Amaranthus retroflexus* L., *A. blitoides* S. Wats.

4. NYCTAGINACEÆ: *Abronia fragrans* Nutt.

5. CRUCIFERÆ: *Capsella Bursa-pastoris* Medik., *Lepidium densiflorum* Schrad., *L. medium* Greene, *Erysimum asperum* DC., *Sophia pinnata*

(Walt.) Britt., *Roripa palustris* (L.) Bess., *Thlaspi arvense* L., *Sisymbrium altissimum* L.

6. CAPPARIDACEÆ: *Cleome serrulata* Pursh.

It will be observed that the above six families constitute two groups. The first four comprise a group of contiguous families, and the last two another group, likewise contiguous but rather remote from the first. *Æcidium fumariacearum* Kell. & Swingle on Corydalis is probably related to *P. subnitens*, though no cultures were made. If this connection should be established it would add another family, Papaveraceæ, contiguous with the second group, a total of seven families.

It is not uncommon to find the aecia in abundance on a half dozen or more host plants at one place, and it manifests only slight racial tendencies, though it seems to infect certain hosts, such as Thlaspi, Kochia, Monolepis, Amaranthus, Roripa, and Erysimum very sparingly. The aecia occur in abundance on plants of all other genera listed above.

Stanleya pinnata (Pursh.) Britt. bears a large orange-red aecium characteristic of *P. subnitens*, however, this host failed to become infected, though seven cultures were made under the same conditions, and with the same material that was used in the successful cultures on other hosts. Cultures were attempted on *Atriplex hastata* L., *A. canescens* James, *A. confertifolia* S. Wats., and *Sarcobatus vermiculatus* (Hook.) Torr. with no results. Arthur has reported successful cultures on *Atriplex hastata* L. with teliospores from Delaware, and on *Sarcobatus vermiculatus* (Hook.) Torr. with teliospores from Nevada. The aecia on the latter host, which closely resemble those of *P. subnitens*, are related chiefly, or entirely, at least in Colorado, to *Puccinia luxuriosa* Syd. on *Sporobolus airoides* Torr., as has been shown by the writer by several successful cultures the past season, both from aeciospores and teliospores, so that there can be no doubt of this relationship. Further, many sowings of teliospores of *P. luxuriosa* on the aecial hosts of *P. subnitens* made through two seasons gave negative results.

Æcidium Abroniæ E. & E. was described on *Abronia* sp. from Fort Collins, Colo. Many cultures both in the field and the garden show that it is the aecial stage of *P. subnitens*. It is common on *Abronia fragrans* Nutt. in Colorado and occasionally collected on *A. elliptica* A. Nels., and *A. micrantha* A. Gray.

Late in the summer cultures were attempted on Beta, Blitum, and Portulaca but no infection resulted, presumably for the reason that the teliospores had probably already germinated. Successful cultures were obtained on either Raphanus, or Brassica, but the plants died before developing sufficiently for determination. The aecium on Cleomella, as noted by Arthur, also is probably related to *P. subnitens*. Cul-

tures will be made again next season on Stanleya, Atriplex, Corydalis, Cleomella, Beta and plants of some other suspected genera, and if these prove to be aecial hosts of this rust, which seems very probable, we shall have a grand total of more than a score of genera in seven families—a remarkably large number of aecial hosts for a single species of rust.

COLORADO STATE MUSEUM
DENVER, COLORADO

CONTRIBUTIONS TO OUR KNOWLEDGE OF THE WHITE PINE BLISTER RUST

W. A. McCubbin

I. MODE OF INFECTION ON THE PINE

Only indefinite references to the method of infection of the pine by *Cronartium ribicola* have appeared in current literature. From these references one gathers the impression that infection takes place through the bark, and probably by way of wounds or abrasions. Having an opportunity for studying a considerable number of pine infections in 1916, some attention was given to this point, and records were made of the origins of cankers where such origins could be determined.

In most cases the determination was not difficult, owing to the fact that in a healthy pine branch the fungus spreads out from the court of entry in a very regular and equal manner, and that its progress is marked by swelling or discoloration or both, or else the cortical tissue is killed in an equally radial fashion. By taking note of this habit one can readily locate the point of original infection in most cases, especially in the earlier stages.

TABLE 1

Records of specific cases to show mode of infection of pines by Cronartium ribicola

LOCALITY	NUMBER OF INFECTIONS	ORIGIN OF LESION		
		Leaf fascicles	Wounds	Undetermined
Secords	177	148	8	21
Four-mile Creek	38	34	1	3
Cookstown	792	743	5	44
Totals	1007	925	14	68

Very early in this study it became apparent that the chief mode of infection was by way of leaf fascicles through the so-called short shoots. In these pines, which were all healthy and which grew in situations where they were fairly free from accidents, wound infection played but a very small part.

According to the tabulated results about 92 per cent of these young blister cankers originate in leaf-bundle infection. This percentage in-

cludes only those cases where the point of origin could be confidently established, but it is highly probable that a large proportion of the number listed as undetermined should also find a place here, and it might not be overstepping the mark to ascribe at least 95 per cent of these blister cankers to leaf fascicle infection.

One may consider that the sporidia from the currant leaves are lodged among the bases of the needles and from this position can then attack the short shoot which bears these leaves. In a number of instances a few of the leaves on such shoots were found to be dead while the rest of those in the fascicle were quite healthy; in other cases all the leaves in the fascicle had been destroyed and often the short shoot and even a small area in the cortex at its base were also killed. In milder cases, especially where the growth of the tree was very vigorous, the fungus did not kill either the leaves or the short shoot, but induced in the latter a pronounced stimulation of growth, so that the short shoot became enlarged and bulbous in appearance.

In these peculiarities of short shoot infection may lie a possible explanation of the year of dormancy which so evidently obtains in a great majority of cases. If, during the summer after infection, the fungus progresses only into the short shoot or slightly beyond it into the adjacent cortex, it would be difficult to recognize these minute symptoms and there would be the so-called dormant year.

II. LIFE CYCLE OF THE FUNGUS ON THE PINE

In general the tendency has been to regard the life of *Cronartium ribicola* on its pine host as more or less indefinite, varying from one to two years up to six years or more; that is, from the time of infection until aecia are produced from one to six years might elapse. In the study of this disease in Ontario in 1916 evidence has come to hand which indicates that the fungus tends to reach the aecial stage in a fairly definite period, but that this normal course of development may be shortened or lengthened because of certain favorable or unfavorable factors.

In the Niagara Peninsula in 1916 there were found a number of young pine infections on trees growing close to black currants, and though these currants have been badly rusted since and including 1914, there is reason to think that no rust was present on them before that season. In any case no sign of infection was visible on these pines in 1915, although they were certainly exposed to infection during the previous year. Moreover, in the summer of 1916 no disease was met with on the growth of 1915 although these pines must have received infection in 1915. On the other hand, these five lots of pines developed 223 infections in 1916, all on the

growth of 1913 and 1914. It seems reasonable to think, therefore, that during the year after infection there are no symptoms of a visible nature in infected pine branches. Additional evidence on this point recently has been obtained from another district (Cookstown, Simcoe County, Ontario), where a young nursery row of white pines was severely infected from black currants growing side by side with them. Out of the 1412 blister cankers recorded from these rows not one was found on the growth of 1915 although the pines were certainly subject to infection in the previous year. On the twig growth of 1914 there occurred some 286 cases, which number gives a strong indication as to the yearly infection that might be expected here.

While the above evidence from these two cases is scarcely conclusive, it is sufficiently extensive and clear-cut to warrant the assumption that in the great majority of cases the season following infection is a "dormant" year.

When the character of all the 509 infections recorded above is examined further another point becomes clear. With one exception all of these cankers were in what might be termed the swelling stage, the cortex being typically swollen into a spindle and usually discolored. If these cankers can be taken to represent the normal course of the disease, and since they include all the infections found on the 1914 twigs of these quite normal trees there seems to be no reason why they should not be so considered,—then the third season of the disease is apparently characterized by the appearance of the first visible symptoms, the swellings just mentioned. And if the formation of aecia from these swellings be assumed to take place during succeeding years a fairly normal life cycle will have been obtained. Summarized it would run thus: first season, infection in summer and autumn; second season, dormant period; third season, swelling stage; fourth season, aecia. There is evidence, however, that in the majority of cases the swelling stage may last for two years before the production of aecia. This evidence has been obtained partly from the Cookstown case already mentioned and partly from the Secord case where 177 swellings were found in 1916 on young pines growing close to black currants. When these 177 swellings were arranged in a curve representing the number of them that had occurred on each year's growth it was found that the apex of the curve came in 1914; that is, there were more infections on the growth made in 1914 than on that of any other year. When a curve was prepared similarly from the data obtained at Cookstown, it was of another type, having the largest number of swellings on the growth of 1913 (fig. 1). The nature of this curve thus suggests very strongly that the swelling stage may ordinarily last two years before the aecia are produced.

It is to be noted that the Cookstown curve represents infections begun in several successive years while the Secord curve contains infections of only one year, that of 1914. An attempt was made to compare the two series of results on a basis of something like equality by supposing that in addition to the infections started in 1914 in the Secord case a similar series of infections had begun in 1913. Assuming that the swellings which would presumably arise from these earlier infections in 1915, would still remain in the same stage during 1916, a curve was then con-

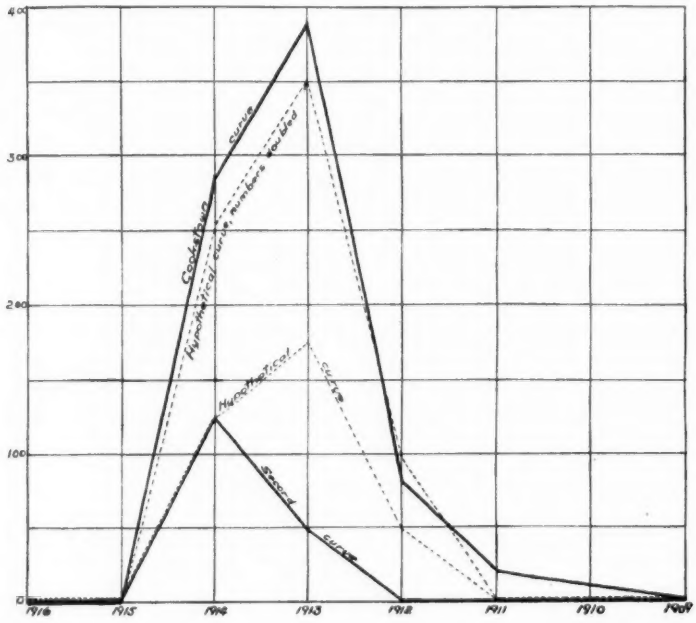

FIG. 1. GRAPH SHOWING NUMBER OF INFECTIONS IN SWELLING STAGE ON THE GROWTH OF EACH INDIVIDUAL YEAR

For explanation see text

structed which would include this hypothetical series of cankers along with those actually present. Such a curve would contain the infections of two successive years and would thus resemble very closely the Cookstown curve. When the numbers in this reconstructed curve were doubled in order to obtain a better comparison with the Cookstown curve, it was seen that except for minor irregularities the two curves are practically identical.

The close concordance of this supposed case with the results of the actual survey provides a striking confirmation of the indication already

given in the Cookstown curve of the continuance of the swelling stage for two years.

The evidence may be presented in another way, by following the course of the disease year by year in a number of shoots of 1911, exposed as in the Cookstown case to a more or less constant annual infection from currants. The number of infections started in these pine twigs in 1911 may be represented by *X*, those started in 1912 by *Y*, and those in 1913 by *Z*. Later infections may no doubt take place in these shoots, but since the number of such infections is known from other considerations to be very small, they may be neglected for the purpose in view. A small letter

TABLE 2

Probable development of the blister rust in pine branches based on a four-years cycle

YEAR	YEARLY PROGRESS OF DISEASE	NUMBER OF SWELLINGS PRESENT EACH YEAR	ESTIMATED PROPORTIONS BASED ON SECORD CASE	COOKSTOWN SURVEY FIGURES
1911	X^i	0	0	0
1912	X^d+Y^i	0	0	0
1913	$X^s+Y^d+Z^i$	X	300	286
1914	$X^b+Y^s+Z^d$	Y	100	390
1915	$X^b+Y^b+Z^s$	Z	10	83
1916	$X^b+Y^b+Z^b$	0	0	22

TABLE 3

Probable development of white pine blister rust in pine branches based on a five-years cycle

YEAR	YEARLY PROGRESS OF DISEASE	NUMBER OF SWELLINGS PRESENT EACH YEAR	ESTIMATED PROPORTIONS BASED ON SECORD CASE	COOKSTOWN SURVEY FIGURES
1911	X^i	0	0	0
1912	X^d+Y^i	0	0	0
1913	$X^s+Y^d+Z^i$	X	300	286
1914	$X^s+Y^s+Z^d$	X+Y	400	390
1915	$X^b+Y^s+Z^s$	Y+Z	110	83
1916	$X^b+Y^b+Z^s$	Z	10	22

attached to each of these symbols conveniently indicates the stage of development, as: *i*, infection year; *d*, dormant year; *s*, swelling stage; *b*, blister or aecial stage.

Using these symbols the accompanying tables have been constructed showing the development of the cankers on these twigs. The first table is based on a four-years cycle, where the swelling stage lasts but one year before aecia are formed, while the second table is based on a five-years cycle, where the swelling stage is continued for two years. In the third column of both tables are entered the number of swellings which will

appear each year, expressed by the symbols adopted. An attempt has been made in the fourth column to substitute values for *X*, *Y*, and *Z*, based on the proportions obtaining in the Secord case. In the Second series the infections begun in 1914 on the growth of 1914, 1913 and 1912 were 127, 49, 0, corresponding to *X*, *Y*, and *Z*, respectively. Adopting 300 as an arbitrary value for *X*, then *Y* becomes approximately 100. *Z* should then be zero, but since there is good reason to think that infections sometimes occur on shoots of three years' standing, though none were found in this case, a nominal value of 10 has been assigned for *Z*.

Beside these estimated proportions in the adjoining column are placed the actual figures of the Cookstown survey. Since these figures indicate the swellings noted at one time on several successive years of growth, they may be used fairly to represent the swellings that would arise on one year's growth in a number of successive seasons. It will be seen at a glance that while the estimated proportions as obtained from the figures of the Secord case do not agree at all with the actual survey figures in the table showing a four-years cycle, there is a strong resemblance between these same two columns in the table where a five-years cycle is used.

It is probable, therefore, that the table giving a five-years cycle expresses more nearly the actual development of the disease than the table giving a four-years cycle; in other words, the normal blister infection on these young pines passes two years in the swelling stage, and the development of the disease as a whole follows this course: First season, infection; second season, dormant period; third season, swelling stage; fourth season, swelling stage; fifth and following seasons, aecia.

The actual time elapsing between infection and the first production of blisters according to this plan of development is something short of four years, but since the course of the disease involves five seasons it seems better for practical reasons to designate it as a five-years cycle.

The above conclusions as to the course of development of the disease on young pines should be fairly trustworthy inasmuch as they are based on a considerable number of blister cankers. On the other hand, there is certain evidence in both the Cookstown and the Secord cases which indicates that precocious or delayed development may occur, and that while the life-cycle outlined may obtain in the majority of cases, it is by no means to be regarded as an invariable rule.

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SPECIES OF MELAMPSORA OCCURRING UPON EUPHORBIA IN NORTH AMERICA

E. B. Mains

No species of Melampsora on Euphorbia was known to occur in the Western Hemisphere until the present year. Collections, however, have been made recently in the United States both upon introduced and native species of Euphorbia. These collections, which Dr. J. C. Arthur has kindly turned over to me for study, consist of one collection upon *Euphorbia commutata* Engelm. from Indiana, four upon *E. robusta* Small from Colorado and Wyoming, and one upon *E. Cyparissias* L. from Maine. Of these, it appears certain that the one on *E. Cyparissias* is introduced and those upon *E. robusta* and *E. commutata* are native.

Up to the present time, six Old-World species of Melampsora upon Euphorbia have been recognized, these being *M. Gelmii* Bres., *M. Euphorbiæ-dulcis* Otth, *M. Euphorbiæ-Gerardianæ* W. Müller, *M. Helioscopiæ* (Pers.) Wint., *M. Euphorbiæ* (Schub.) Cast. and *M. Euphorbiæ-Engleri* P. Henn. all of which have very similar uredinia and urediniospores, the separation being by telia and teliospores. Of these the first three are well-marked and distinct species. Of the last three, *M. Helioscopiæ* and *M. Euphorbiæ* while distinguished from the rest by well-marked characters, are separated from each other, according to Müller (1907) only by a rather small difference in the length of the teliospores. This difference may be a real one but is scarcely apparent in such European exsiccati of the two rusts as the author has at his disposal for examination. The last, *M. Eurphorbiæ-Engleri* is a species of doubtful validity. It was set apart by Hennings, owing to its habit of maintaining itself wholly by the uredinia, other spore forms never having been found. This is only known on one species of host.

A study of the North American collections of 1916 shows that they can be readily placed in three species, two of which correspond to two of the above and one of which appears to be undescribed. The Maine collection, which is upon *Euphorbia Cyparissias*, has teliospores which in length and uniform thickness of wall agree very well with *M. Euphorbiæ* upon the same host in Europe, while the Indiana collection upon *E. commutata* with its 31–58μ long and apically thickened (3–6μ) teliospores agrees very well with European material of *M. Euphorbiæ-Gerardianæ*,

the urediniospores of all being similar. The collections upon *Euphorbia robusta* from Colorado and Wyoming, however, are distinguished from all other species of Melampsora upon Euphorbia by certain characters of the uredinia and urediniospores and are considered by the writer as belonging to an undescribed species.

The North American species of Melampsora upon Euphorbia may be keyed out as follows:

Urediniospores 16–23 μ long, paraphyses numerous
  Teliospores decidedly thickened at the apex.....1 *M. Euphorbiæ-Gerardianæ.*
  Teliospores not or only slightly thickened at the apex.....2 *M. Euphorbiæ.*
Urediniospores 16–29 μ long, paraphyses few..3 *M. monticola.*

1. *Melampsora Euphorbiæ-Gerardianæ* W. Müller, Centr. Bakt. **17**^{2}: 210. 1906.

O and I. Pycnia and aecia unknown.

II. Uredinia amphigenous and caulicolous, scattered, circular, 0.2–0.5 mm. in diameter, subepidermal, soon naked, pulverulent, pulvinate due to the crowded paraphyses, pale yellow, ruptured epidermis inconspicuous; paraphyses numerous, intermixed with the spores, capitate, 16–19 by 51–58μ, the wall colorless, 2–3μ thick; urediniospores globoid to ellipsoid, 13–16 by 16–20μ; wall colorless, 2–3μ thick, finely and closely echinulate, the pores obscure.

III. Telia caulicolous, probably also amphigenous, circinating about the uredinia, oblong, 0.2–1 mm. long, subepidermal, slightly elevated, blackish-brown; teliospores prismatic, 9–15 by 31–60μ, rounded at both ends; wall light chestnut-brown, darker towards the apex, 1.5μ thick, 3–6μ at the apex.

ON EUPHORBIACEÆ

Euphorbia commutata Engelm., West side of High Lake, Noble Co., Indiana, June 11, 1916, II, III, *C.C. Deam 20083A*, communicated by G. N. Hoffer.

This collection, which is the first collection of a Melampsora upon Euphorbia to be reported for North America, has a range in the length of the teliospore somewhat less than that given by Müller (1907, p. 641) for *M. Euphorbiæ-Gerardianæ* in Europe. A comparison with European material upon *E. falcata* (Sydow Ured. no. 1687) shows a very close agreement, however, both as to the urediniospores and teliospores. The teliospores are not quite so generally thickened at the apex as in the European specimen but still are very decidedly thickened, up to 3–6μ, while the uredinia have the usual pulvinate appearance and abundant paraphyses.

Pycnia and aecia are not known for this species but will doubtless be found upon the same host, since *M. Helioscopiæ*, *M. Euphorbiæ* and *M.*

Euphorbiæ-dulcis, the three species of Melamspora upon Euphorbia whose pycnial and aecial stages are known, are autoecious.

2. *Melampsora Euphorbiæ* (Schub.) Cast. Observ. Myc. **2**: 18. 1843.
Uredo Euphorbiæ-Helioscopiæ Pers. *β Euphorbiæ-exiguæ* Pers. Syn. Fung. 215. 1801.
Xyloma (*Placuntium*) *Euphorbiæ* Schubert *in* H. Ficinus Flora der Gegend um Dresden **2**: 310. 1823.
Uromyces verrucipes Vuill. Bull. Soc. Bot France **41**: 285. 1894.
Melampsora Euphorbiæ-exiguæ W. Müller, Centr. Bakt. **17**[2]: 210. 1906
Melampsora Euphorbiæ-Pepli W. Müller, Centr. Bakt. **17**[2]: 210. 1906.
Melampsora Euphorbiæ-Cyparissiæ W. Müller, Centr. Bakt. **19**[2]: 453. 1907.
Melampsora Cyparissiæ W. Müller, Centr. Bakt. **19**[2]: 561. 1907.

O.[1] Pycnia flattened hemispherical; ostiolar filaments none.

I. Aecia foliicolous and caulicolous, circular to oblong, 0.2–0.5 mm. in diameter on the leaves, 1–4 mm. long on the stems, orange-yellow, without peridium or paraphyses; aeciospores spherical to ellipsoid, 19–24 by 21–28μ; wall closely verrucose.

II. Uredinia amphigenous and caulicolous, scattered, circular or oval, 0.1–0.3 mm. long, early naked, pulverulent, pulvinate from the mass of paraphyses, golden-yellow fading to white, ruptured epidermis inconspicuous; paraphyses intermixed with the spores, numerous, capitate, 16–20 by 31–51μ; wall colorless, 3–4μ thick, smooth; urediniospores globoid to ellipsoid, 13–19 by 17–23μ; wall colorless, 2–3μ thick, closely and finely echinulate, the pores obscure.

III. Telia amphigenous and occasionally caulicolous, scattered, circular to oval, small, 0.1–0.2 mm. long, covered with the epidermis, compact, pulvinate, dark chocolate-brown; teliospores prismatic, 7–13 by 32–45μ; wall chestnut-brown above, lighter below, 1–1.5μ thick, not thickened at the apex, smooth.

ON EUPHORBIACEÆ

Euphorbia Cyparissias L., Bank near Turner graveyard, Isle au Haut, Maine. Sept. 13, 1916, II, iii, *J. C. Arthur*.

3. **Melampsora monticola** sp. nov.

O and I. Pycnia and aecia unknown.

II. Uredinia amphigenous and caulicolous, scattered or in circular groups, circular or oblong, 0.2–2 mm. long, subepidermal, long covered by the epidermis, pulverulent, orange-yellow, ruptured epidermis conspicuous; paraphyses few, intermixed with the spores, capitate, 13–21 by 32–58μ, the wall colorless, 1.5–3μ thick, smooth, the stipe solid; urediniospores globoid, ellipsoid or obovoid, 13–20 by 16–29μ; wall colorless, 1.5–3μ thick, finely and closely echinulate, the pores obscure.

III. Telia amphigenous and caulicolous, circinating about the uredinia, circular or oblong, 0.1–1 mm. long, subepidermal, slightly elevated, blackish-brown; teliospores prismatic, 9–16 by 27–56μ, rounded at both ends;

[1] Description of pycnia and aecia adapted from Dietel (1895).

wall light chestnut-brown below, darker towards the apex, 1.5–2μ thick, 2–4μ at the apex.

ON EUPHORBIACEÆ

Euphorbia robusta Small, Carpenter, Wyoming, Aug. 18, 1916, II, iii, *E. T. & E. Bartholomew 6067* (*Uromyces Tranzschelii* Sydow, 0, III, also present); Colorado Springs, Colorado, plains 10 miles east of city, Aug. 31, 1916, II, iii, *E. Bartholomew, 6104* (type); Palmer Lake, Colo., Sept. 23, 1916, II, III, *E. Bethel* (two collections).

In the younger uredinia, especially, apparently thinner walled urediniospores are often seen mixed with the thicker. After treatment with lactic acid, which serves to differentiate the wall from the cell contents and make it stand out more clearly, the apparent difference is not to be observed.

This species is distinct from other species of Melampsora on Euphorbia. The uredinia are abundant, large, and long covered by the epidermis and since they contain but few paraphyses, after the rupture of the covering epidermis and the escape of the pulverulent mass of spores, they possess a flattened appearance when contrasted with the pulvinate mass of paraphyses of other species on Euphorbia. The urediniospores are much more variable and larger in size than those of the other species.

No pycnia or aecia were found upon any of the collections. They are, however, to be looked for upon the same host earlier in the season since the rusts of this group whose life cycle are known are autoecious with all spore forms, although Jacky (1899) working with *M. Euphorbiæ* on *E. Cyparissias* and Müller (1907 p. 449) working with the same rust on *E. Peplus* claim to have obtained uredinia by infection from teliospores, yet Dietel (1895) working with *M. Euphorbiæ* on *E. Cyparissias*, and Müller (1907) with the same rust on *E. exigua* on the other hand have shown that pycnia and aecia are produced upon these hosts from infections with the teliospores. Dietel (1889) has also shown that *M. Euphorbiæ-dulcis* Schroet. has pycnia and aecia. Since these stages are developed sparingly, it is probable that the first workers overlooked them and that *M. Euphorbiæ* has all spore forms. Although all the North American collections were examined for pycnia associated with the uredinia none were found, and it is probable that all of these rusts will be found to be autoecious and have all spore forms.

It is interesting to note that from a region in which this group has hitherto not been known so many collections from such widely separated areas should have all been made in one season. It is not so surprising that *M. Euphorbiæ* should be found upon *E. Cyparissias*, as the latter has been brought into this country from Europe and it is likely that the rust was introduced with it. It is, however, surprising that the rust has not previously been found since the host is rather widely distributed.

The other two species of Melampsora are upon native species of Euphorbia and of these *M. monticola* is evidently a purely American species found upon a common western Euphorbia.[2] With its abundant, large, orange-yellow uredinia, it is remarkable that this very striking rust has not been collected before. The other species, *M. Euphorbiae-Gerardianae,* is probably native to this country as well as to Europe, since its European hosts, *E. Gerardiana* and *E. falcata* are not known in this country. Another argument in favor of this assumption is that the species of Melampsora on Euphorbia have in most cases physiological races limited to one species of host as Müller (1906, 1907) has shown. Consequently even if European hosts were found, it would be doubtful if rusts on American species could be considered as having an European origin.

The writer wishes to express his deep appreciation to Dr. J. C. Arthur and Prof. H. S. Jackson for the helpful suggestions and criticism received in the preparation of this paper.

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[2] In a communication recently received from Mr. E. Bethel he says, "The one [*M. monticola*] we have here is undoubtedly native as I found it in the high mountains (above 9000 feet) at Nederland, Colo."

RECENT CULTURES OF FOREST TREE RUSTS

JAMES R. WEIR AND ERNEST E. HUBERT

The determination of various species of rusts found on forest trees of the general region of Montana is a difficult task when descriptive evidence and spore measurements are used. In most cases involving heteroecious rusts successful inoculation is considered very necessary in determining the identity of the species under consideration. Consequently, as a beginning, an attempt was made early in March, 1916, to secure various forms of hypertrophy formed by the bark-inhabiting Peridermia. After collecting, these were placed in the laboratory in large test-tubes with sufficient water to supply the branch or twig supporting the infection. Many needles were always left on the branches or twigs. In this manner the fungus in many of the infections was induced to produce spores prematurely and these were available for culture work at an early date. This process also served to develop successfully the pycnial stage of *Cronartium coleosporoides* (D. & H.) Arth. and *Cronartium Comptoniæ* Arth. which stage preceded the aecial stage in both cases. In the search for material a foliicolous rust on the needles of *Larix occidentalis* was collected for the first time in June, 1916, at various points in Montana and Idaho. The rust was very abundant and widespread. All the caulicolous forms of rusts on forest trees in this region and in the states of Michigan and Minnesota as well as a number of the foliicolous forms were tried on a variety of suspected hosts. All inoculations were isolated at the greenhouse at Missoula, Montana, by the use of celluloid cylinders and cotton plugs. The inoculated plants were sprayed daily with tap water for a period of three to five days following inoculation. The following is a summary of the cultures to date since the last report.[1]

Five plants of *Castilleja angustifolia*, two on May 14, 1916, and three on May 8, 1916, were dusted with newly developed aeciospores (forced in laboratory) of *Cronartium coleosporoides* (D. & H.) Arth. (*P. stalactiforme* type) on *Pinus contorta* from Hayden Lake, Idaho. Of the first two plants one developed uredinia on May 26 and telia on May 29, the remaining plant dying before May 24. Of the other three plants, two

[1] Weir, J. R., and Hubert, E. E. Successful inoculations of Larix occidentalis and Larix europea with Melampsora bigelowii. Phytopath. **6**: 372-373. Ag. 1916.

Weir, J. R. and Hubert, E. E. A successful inoculation of Abies lasiocarpa with Pucciniastrum pustulatum. Phytopath. **6**: 373. Ag. 1916.

developed uredinia on May 30, followed by abundant telia on June 3. The remaining plant wilted. Four control plants remained normal. This checks the cultures of 1915.[2]

Three plants of *Castilleja angustifolia* were dusted with aeciospores of *Cronartium coleosporoides* (typical gall form) on *Pinus contorta* from Sylvanite, Montana, June 23, 1916. Uredinia were not observed but on July 17, 1916, telia appeared uniformly on all three of the trial hosts. Three control plants remained normal. A similar result was obtained on Castilleja with aeciospores from the gall type on *Pinus contorta* from Evaro, Montana. Telia were recorded July 17, 1916, on one of three trial-hosts. The remaining plants died. Three control plants remained normal.

On May 23, 1916, aeciospores of *Cronartium coleosporoides* (blister type) on young seedlings of *Pinus ponderosa* from Haugan, Montana, were dusted on three plants of *Castilleja angustifolia*. Heavy infections on two and a light infection on one with uredinia on June 5 and telia on June 8 were recorded. Three control plants remained normal. This result also checks similar cultures made in 1915.[3]

On June 21, 1916, aeciospores of *Cronartium coleosporoides* (typical gall form) on 18-years-old trees of *Pinus ponderosa* from Sylvanite, Montana, were dusted on three plants of *Castilleja angustifolia*. The appearance of the uredinia was not recorded owing to absence from the laboratory but on July 17, 1916, telia were noted in abundance on two of the inoculated plants. The other trial-host died. Three control plants remained normal.

The results of the season together with those of 1915 demonstrate that the various caulicolous forms of rusts occurring on *Pinus contorta* and *P. ponderosa* in the Rocky Mountain region are the aecial stage of *Cronartium coleosporoides*. It is not only possible but very probable that the same forms on *Pinus contorta* and *P. ponderosa* as known elsewhere in the western United States belong here also. An examination of the aeciospores from galls on *Pinus contorta*, *P. ponderosa*, *P. attenuata*, *P. coulteri*, and *P. jeffreyi*, from widely separate regions has not brought out any specific characters different from that of the material used in the successful cultures on Castilleja. Attempts were made to infect young leaves of *Quercus rubra* with aeciospores from galls on *Pinus contorta* and *P. ponderosa* but without success.

Aeciospores of *Cronartium Comptoniæ* Arth. on *Pinus banksiana* from Cass Lake, Minnesota, were sown on trial-hosts as follows: On two plants of *Castilleja angustifolia* on May 17, 1916, with negative results; on one

[2] Weir, J. R., and Hubert, E. E. A serious disease in forest nurseries caused by Peridermium filamentosum. Jour. Agr. Research **6**: 781-785. Ja. 24, 1916.

[3] Jour. Agr. Research **6**: 781-785. 24 Ja. 1916.

plant of *Quercus rubra* on May 18, 1916, with negative results; on one plant of *Comptonia asplenifolia* on May 18, 1916, with positive results, uredinia appearing on June 9 and telia on June 17. All control plants remained normal.

Aeciospores of *Cronartium Comptoniæ* Arth. on *Pinus banksiana* from East Tawas, Michigan, were sown on trial-hosts as follows: On three plants of *Castilleja miniata* on May 24, 1916, with negative results; on one plant of *Quercus rubra* on May 24, 1916, with negative results; on two plants of *Comptonia asplenifolia* on May 23, 1916, and June 13, 1916, respectively. Uredinia were noted on June 13 and telia on June 23 on the first plant and uredinia on June 30 on the second. Two control plants remained normal. Aeciospores were sown on one plant of *Myrica carolinensis* and one of *Myrica gale* on May 26, 1916. Uredinia on June 13 and telia on June 25 were noted on both plants. Two control plants remained normal.

A collection of leaves of the previous season (1915) of *Populus tremuloides* bearing telial sori of *Melampsora medusæ* Thüm. was made in Pattee Canyon two miles southeast of Missoula, Montana, on March 12, 1916. A portion of these over-wintered leaves were placed in moist chambers on March 15, 1916, and a few days later upon examination of the yellowish-brown, downy layer formed on the sori, it was found that sporidia were present. These fresh sporidia were used to inoculate newly formed needles of *Larix occidentalis*. Two separate inoculations were made on March 22, 1916, followed by two others on March 26, 1916. Individual branches of trees of *L. occidentalis* were used for the test. On April 3, the first inoculation had resulted in pycnia which were accompanied by small drops of hyaline liquid. On April 4 the aecia were present on the under side of the needles. The second inoculation gave pycnia and aecia on April 4, the third and fourth inoculations resulting in pycnia and aecia on April 8. The four control plants of *L. occidentalis* as well as the needles on the inoculated trees which were not included within the cylinders remained normal. All the needles subjected to the inoculation became infected and developed a large number of sori of both stages (O and I) of the rust.

On April 9, 1916, germinating teliosporic material of *Melampsora medusæ* Thüm. on *Populus tremuloides* was sown on two small trees of *Larix europea*. On April 26, an abundant development of pycnia were recorded and on May 1 the aecia appeared. The pycnia and aecia and their respective spore-forms on the two species of larch were found upon examination to be identical. The telial material failed to infect *Tsuga heterophylla* and *Pseudotsuga taxifolia*. The control plants in all cases remained normal.

Teliospores bearing sporidia of *Melampsora medusæ* Thüm. on leaves of *Populus trichocarpa* were collected at Haugan, Montana, on June 5, 1916.

On June 7, these were sown on one small tree of *Larix europea*, two of *L. occidentalis*, one each of *Tsuga heterophylla*, *T. caroliniana*, and *Pseudotsuga taxifolia*. On June 15, pycnia appeared on the needles of *L. europea* and on the needles of the two trees of *L. occidentalis*. Aecia developed on *L. europea* in abundance on June 24 and on *L. occidentalis* on June 22. Negative results were secured on *Tsuga heterophylla*, *T. caroliniana*, and *Pseudotsuga taxifolia*. Control plants remained normal.

Teliospores bearing sporidia of *Melampsora bigelowii* Thüm. on *Salix cordata mackensiana* from Deborgia, Montana, were sown on *Larix occidentalis* and *L. laricina* on June 7, 1916. One small tree of each species was used. Pycnia appeared on June 15 and aecia on June 18 on the needles of *L. occidentalis*. On *L. laricina*, the pycnia were noted on June 15 and the aecia on June 18. A heavy infection occurred. Control plants remained normal.

Aeciospores of *Pucciniastrum pustulatum* (Pers.) Diet. on *Abies lasiocarpa* resulting from an inoculation with the telial stage on *Epilobium angustifolium*[4] were sown on two plants of *Epilobium angustifolium* on May 18, 1916. Uredinia developed on June 4, on the underside of a majority of the leaves subjected to the spores. Only the younger leaves became infected. Control plants remained normal. This completes the cycle for *Pucciniastrum pustulatum*.

Teliospores of *Gymnosporangium tubulatum* Kern on *Juniperus scopulorum* from Missoula, Montana, were sown on two plants of *Cratægus douglasii* on April 27, 1916. Pycnia in abundance appeared on May 8 and 11 and aecia on May 22 and 24. Control plants remained normal. This checks a previous culture.[5]

Teliospores of *Gymnosporangium nelsoni* Arth. on *Juniperus communis* from Bonner, Montana, were sown on two plants of *Amelanchier alnifolia* on May 21, 1916. On June 9, pycnia appeared in abundance, the aecia developing on June 28. Control plants remained normal.

Teliospores of *Gymnosporangium nelsoni* Arth. on *Juniperus scopulorum* from Bonner, Montana, were sown on two plants of *Amelanchier alnifolia* on May 21, 1916. Pycnia appeared on June 6; aecia were noted to be developing on June 28. Control plants remained normal

Several of the cultures are still in progress of development and as soon as results on these are secured further information on the rusts of forest trees in this region will be available.

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[4] Phytopath. **6**: 373. Ag. 1916.

[5] Weir, J. R. Telial stage of Gymnosporangium tubulatum on Juniperus scopulorum. Phytopath. **5**: 218. Ag. 1915.

A RHIZOCTONIA OF THE FIG

J. Matz

With Plate II and Three Figures in the Text

A fungus possessing characteristics common to Rhizoctonia was observed to occur in the years 1915 and 1916 on leaves, twigs and fruit of the fig, *Ficus carica*, at Gainesville, Florida. Superficial, silvery to yellowish white, thin mycelial strands of this fungus can be seen to radiate loosely from yellow to dirty brown infection centers in the fig leaves and spread over the surrounding green tissue. Later as more of the green tissue becomes discolored by the invading mycelium, the upper surfaces of these enlarged brownish areas become silvery white and dry, the mycelial strands become less, if at all visible, while the under surfaces at the corresponding points remain light brown to brown and are usually covered with a visible web of mycelium (fig. 1). Small, immature white, as well as mature brown to dark brown sclerotia attached to mycelial threads are often found on the petioles and midribs of infected leaves, but seldom are sclerotia found on the blades of such leaves. Loosely woven, silky strands of the mycelium of this fungus may be traced to some distance on the twigs. More or less dense accumulations of sclerotia are usually grouped on one side of the twig (plate II, fig. 2). No direct injurious effect was observed to have been caused to the twigs by the fungus. The fruit of the fig may become more or less covered by the spreading mycelium. Numerous sclerotia are then produced which cling by means of mycelial threads to the fruit and its stalk (plate II, fig. 1).

Portions of diseased fig leaves, and parts of twigs upon which mycelium and sclerotia were plainly visible, were killed and fixed in Carnoy's fluid and embedded in paraffin. Cross-sections of the leaf tissue reveal hyphae penetrating through the stomata into the parenchyma (plate II, fig. 4), while cross and longitudinal sections of the twig tissues do not show the presence of a penetrating mycelium.

This fungus was isolated from the diseased tissues of fig leaves, where mycelium but no sclerotia were present; and from single sclerotia taken from twigs. The pure cultures from both sources were alike in every respect. Pure cultures of this fungus were grown easily for over eighteen months on standard nutrient agar, corn meal agar, and sterilized green

bean pods. In culture this fungus does not differ markedly from its appearance on the host.

This fungus was proved to be the cause of a leaf blight of the fig[1] by repeated infection of healthy fig trees with pure cultures, with the production of typical lesions and by reisolation of the organism.

No spores of any kind were found to be produced by this fungus. Besides being sterile, the fungus has sclerotia connected with fibrils and thus should belong to the genus Rhizoctonia (plate II, figs. 5 and 6). Moreover, its mycelium is in all respects precisely of the same type as that of the other well-established species of this genus, such as *R. Solani* Kuhn and *R. crocorum* (Pers.) DC (fig. 3).

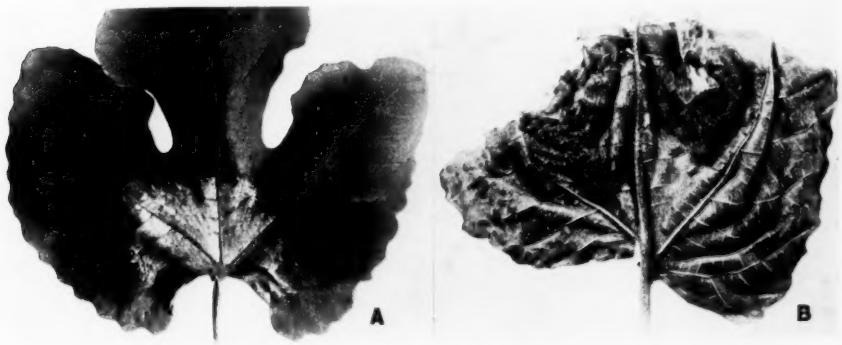


FIG. 1. FIG LEAVES ATTACKED BY RHIZOCTONIA MICROSCLEROTIA

A, Upper surface of leaf showing silvery white, dry area and mycelial strands on the surrounding green tissue. × 0.5. *B*, Under surface of diseased leaf. × 0.5.

So far this fungus has not been definitely connected with a perfect stage, although in August of 1916 a few scattered and not fully developed specimens of a Corticium was found in association with the typical sclerotia and mycelium of this Rhizoctonia, on a fig tree which was inoculated the year before with a pure culture of the latter. According to Dr. E. A. Burt's advice, apparently this Corticium is different from *C. vagum* B. & C. and is better referable to *C. Salmonicolor*, Br. & Brs. Several attempts to germinate the spores of this Corticium by plate dilutions and by the method employed by Rolfs[2] to germinate the spores of *C. vagum*, has not proven successful.

[1] An account of the relation of this fungus to the leaf blight of the fig is given in the Florida Experiment Station Annual Report for 1915–1916, to be published in the near future.

[2] Rolfs, F. M. Potato failures. Colorado Agr. Exp. Sta. Bul. 91: 1–33, 5 pls. 1904.

FIG. 2. BLIGHTED FIG FOLIAGE DUE TO RHIZOCTONIA MICROSCLEROTIA

Numerous sclerotia are adhering, by means of slender mycelial threads, to the petioles, stems of fruit and branch. × 0.5.

Of the previously described species of Rhizoctonia the following should be considered here:

Dr. Peltier[3] in a recent publication on parasitic Rhizoctonias in America summarizes as follows: "At the present time there are recognized in America two species of truly parasitic Rhizoctonias; the common form *Rhizoctonia Solani* Kühn (*Corticum vagum* B.& C.), widely distributed and occurring on a great number of hosts; and *R. crocorum* (Pers.) DC., with a limited distribution on alfalfa and potato tubers. A third Rhizoctonia, *Corticum ochraleucum* (Noack) Burt, is found on the leaves of pomaceous fruit trees, while a fourth species isolated from damped-off

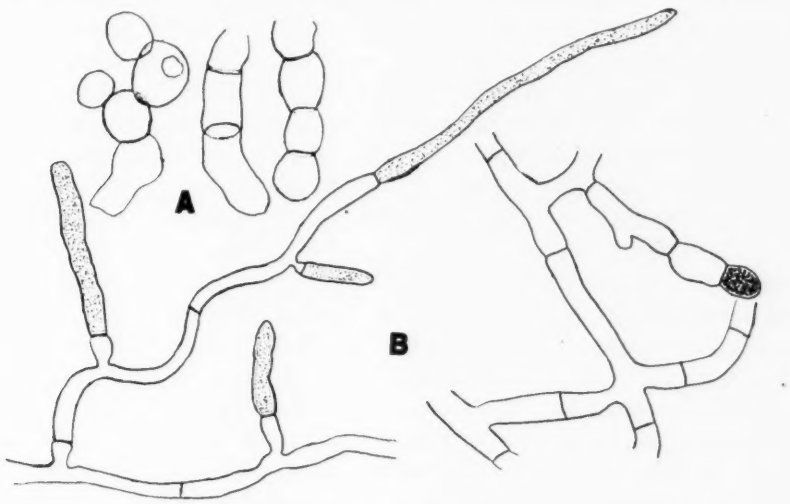


FIG. 3. MYCELIUM OF RHIZOCTONIA MICROSCLEROTIA

A, Short chains and a group of short cells from the margin of young sclerotia. × 333.3. *B*, Vegetative mycelium from a young agar culture on the left, and from an old culture on the right. × 333.3.

onion seedlings is of questionable parasitism." In discussing the growth characters of a number of strains of Rhizoctonia, Peltier[3] makes the following statement (p. 370) regarding the species isolated from damped-off onion seedlings: "The strain from onion produced sclerotia which were entirely different from those of other strains in that they were small (0.5 to 1 millimeter in diameter), perfectly round, bright colored, and developed submerged in the medium." None of these latter characters have been observed in the Rhizoctonia from the fig. The sclerotia of

[3] Peltier, Geo. L. Parasitic Rhizoctonias in America. Illinois Agr. Exp. Sta. Bul. 189:—1916.

this fungus are roundish or oblong, from 0.2 to 0.5 millimeters in diameter, are not bright colored and are produced freely on the surface of but not in the medium in culture.

The effects and manner of attack of *Corticium ochraleucum* (Noack) Burt on pomaceous fruits, as described by Stevens and Hall,[4] are similar to those of the fig Rhizoctonia on its host. However, the sclerotia of the two fungi are entirely different and the perfect stage of the former has not so far been found in connection with the fig Rhizoctonia on fig trees.

Duggar[5] in his recent paper gives sufficient evidence that the common Rhizoctonia in America is *Rhizoctonia Solani* Kühn. This Rhizoctonia has *Corticum vagum* B. & C. as its perfect stage. In comparing the Rhizoctonia of the fig with the *Rhizoctonia Solani* Kühn, obtained from bean seedlings here, the two show pronounced differences on sterilized bean plug and agar slant cultures. On each medium the sclerotia of the first are white at first, turning dark brown with age, and remain small and more or less globose; the sclerotia of the second are white at first, turning light brown to brown or dark brown and are very irregular in size and form (plate II, fig. 6). Mycelium and sclerotia from pure cultures of the fig Rhizoctonia and from *R. Solani* Kühn were placed on moist and growing fig leaves and twigs. Both fungi killed areas in the leaf tissue but *R. Solani* did not produce any scleortia on the infected parts. Two separate flats of cowpea seedlings were inoculated with the two fungi. *R. Solani* killed 90 per cent of the seedlings, while the fig fungus did not produce any injury to the young plants.

Shaw[6] in his account of a Rhizoctonia which he found on jute, mulberry, cotton, and cowpea, and which he apparently misnames *Rhizoctonia Solani* Kühn, illustrates a fungus which is similar to the Rhizoctonia of the fig in several respects, i.e., the normal occurrence of its numerous, comparatively small, rounded sclerotia on the tips and stems of its respective host plants. However, the diameter of the sclerotia of Shaw's Rhizoctonia is about half of that of the fig Rhizoctonia; the color of the sclerotia of the former is black, while that of the latter is brown to dark brown. Shaw's illustrations (plate IX) indicate a distinct cortex in the sclerotia of his Rhizoctonia, which formation is absent in

[4] Stevens, F. L. and Hall, J. G. Hypocnose of pomaceous fruit, North Carolina Agr. Exp. Sta. Rep. **1908–09**: 32, 76–85, figs. 41–48, 1911.

[5] Duggar, B. M. Rhizoctonia crocorum (Pers.) D. C. and R. Solani Kühn (Corticium vagum B. & C.) with notes on other species. Ann. Missouri Bot. Gard. **2**: 403–458. 1915.

[6] Shaw, F. J. F. Morphology and parasitism of Rhizoctonia. Mem. Dept. Agr. India. **4**: 144. 1912.

——— The Genus Rhizoctonia in India. Mem. Dept. Agr., India. **7**: no. 4. 1915.

those of the fig. The mode of origin, as described by Shaw, of the sclerotia of the first, has not been observed in the fig fungus.

In culture the sclerotia of the fig fungus develop from dense masses of short hyphae and there the young sclerotia are usually surrounded by short chains and groups of ovoid, short, sometimes elbowed cells.

Zimmerman[7] in describing *Corticum javanicum* on *Coffea arabica*, *Coffea liberica* and several other plants, mentions the occurrence of a sterile mycelium and small (0.15 to 0.3 millimeter in diameter) white sclerotia-like bodies (weisse Kugelen) in association with this Corticum. He states: "dieselben treten sowohl auf der Ober—als auf der Unterseite der Zweige auf und sind ausserdem auch namentlich häufig an den Früchten zu finden;" but no mention is made of its occurrence on leaves. In describing the effects of this fungus on the host, Zimmerman says, "Die unter den Kugelen gelegenen Pflanzenteile sterben—zum mindsten in den nahe der oberfläche gelegenen schichten—ab und erhalten eine dunkelbraune bis schwarze Färbung;" but no direct injurious effect from the sclerotia of the fig fungus was observed on the branches of its host. Regarding the "Kugelen" of Zimmerman's fungus he states: "vertrocknen sie einfach an den zweigen, auf denen sie sitzen." No mention is made here of the change in color which is a dark brown in the sclerotia of the fig fungus at maturity.

Edgerton[8] described a limb blight of the fig, due to *Corticum lætum* Kars. This disease is characterized according to Edgerton's illustrations and descriptions, mainly by the conspicuous fruiting layer of the fungus associated with the diseased parts of the host, but no mention is made of any Rhizoctonia occurring on fig trees afflicted with limb blight.

Kuijper[9] describes a leaf disease of *Coffea arabica* and *Coffea liberica* under the name of "Zilverdraadziekte der Koffie," in Surinam. There is a striking similarity in the character, the manner of attack, and effects of the sterile fungus which causes the Silverdraad disease on *Coffea*, to the Rhizoctonia of leaf blight of the fig. In describing the *Coffea* fungus, Kuijper does not mention nor illustrate anything which approaches a semblance of the dark brown sclerotia which are commonly found in connection with the fig fungus on its host and in pure culture. The sclerotia of the latter are not identical with Kuijper's "hyphenkluwens." These forms occur also in his cultures. He states: "Op plaatsen, waar veel, zijtakken ontstaan strengelen deze zich door elkaar, zoodat op de

[7] Zimmerman, A. Ueber einige an Tropischen Kulturpflanzen beobachtete Pilze I. Centbl. Bact. Abt. II, **7**: 102. 1901.

[8] Edgerton, C. W. Louisiana Agr. Exp. Sta. Bul. 126: 13, pl. VII, fig. 1. 1911.

[9] Kuijper, J. De Zilverdraad-ziekte der Koffie in Suriname. Dpt. van den Landbouw, Suriname. Bul. **28**:—1912.

bladeren beschreven kluwens ontstaan." In some of his cultures Kuijper obtained "hyphen-opeenhoopingen zoo sterk, dat bijna bolformige lichaampjes van 1 à 2 m.m. doorsnede ontstaan, die bestaanuit een betrekkelijk los hyphenvlechtwerk." Apparently these bodies never become in Kuijper's cultures as compact and colored as do the sclerotia of the fig fungus on various media and on the host.

Brooks and Sharples[10] in their work with *Corticium salmonicolor* B. & Br. (*C. javanicum* Zim) describe four forms in which the fungus appears on rubber trees as follows: "a pink incrustation on the branches or main stem; . . . . white or pale pink pustules arranged more or less in lines parallel with the branches; . . . . part of the fungus on the exterior consists of white or pale pink strands of a cobweb-like texture, which run irregularly downwards over the surface, the strands being sometimes so delicate as to be overlooked; . . . . finally there is the Necator stage. . . . . consists of orange-red (not pink) pustules about one-eighth inch in diameter." In their pure cultures of *C. salmonicolor*, the above authors observed clamp connections in old as well as young cultures, a pink to a bright rose coloration and, "aggregations of hyphae . . . . resembled a number of closely attached Necator pustules." Practically none of these characters were observed in the fig fungus.

From the preceding discussion it follows then that the Rhizoctonia of the fig leaf blight is different from all the true species of Rhizoctonia previously described and thus it should be considered as a new organism which can briefly be described as follows:

Rhizoctonia microsclerotia n. sp.

Sclerotia superficial, small 0.2 to 0.5 millimeters in diameter, white when young, brown to dark brown at maturity, nearly homogenous in structure and color, sub-globose, free from tufted mycelium, not smooth usually single, sometimes conglomerated.

Vegetative hyphae 6 to 8 μ wide, first hyaline and granular, brown and more or less empty with maturity, septate.

Hab. On living leaves, branches and fruit of the cultivated fig, *Ficus carica*, Gainesville, Florida, U. S. A.

[10] Brooks, F. T. and Sharples, A. Pink disease. Dept. of Agri. Federated Malay States. Bul. 21: 1–27, fig. 19. 1914.

Rhizoctonia microsclerotia Sp. Nov.

Tuberculis superficialibus, minusculis, 0.2 to 0.5 millimeters in diameter, primum albis deinde fusco-bruneis (intus idem quod extus), similibus fere forma et colore intus ac extus, sub-globosis, floccis myceliaribus deficientibus, non glabris, saepius singulatis, non-nunquam conglomeratia.

Hyphis 6–8 μ, latis, primum hyalinis granulosis deinde bruneosis, septatis.

Hab. in foliis, ramis ac fructibus vivis Fici caricae cultae, Gainesville, Florida, Am. Bor.

UNIVERSITY OF FLORIDA EXPERIMENT STATION
GAINESVILLE, FLORIDA

PLATE II. RHIZOCTONIA MICROSCLEROTIA ON FIG

FIG. 1. R. microsclerotia covering a twig and fruit of the fig. × 1.5.

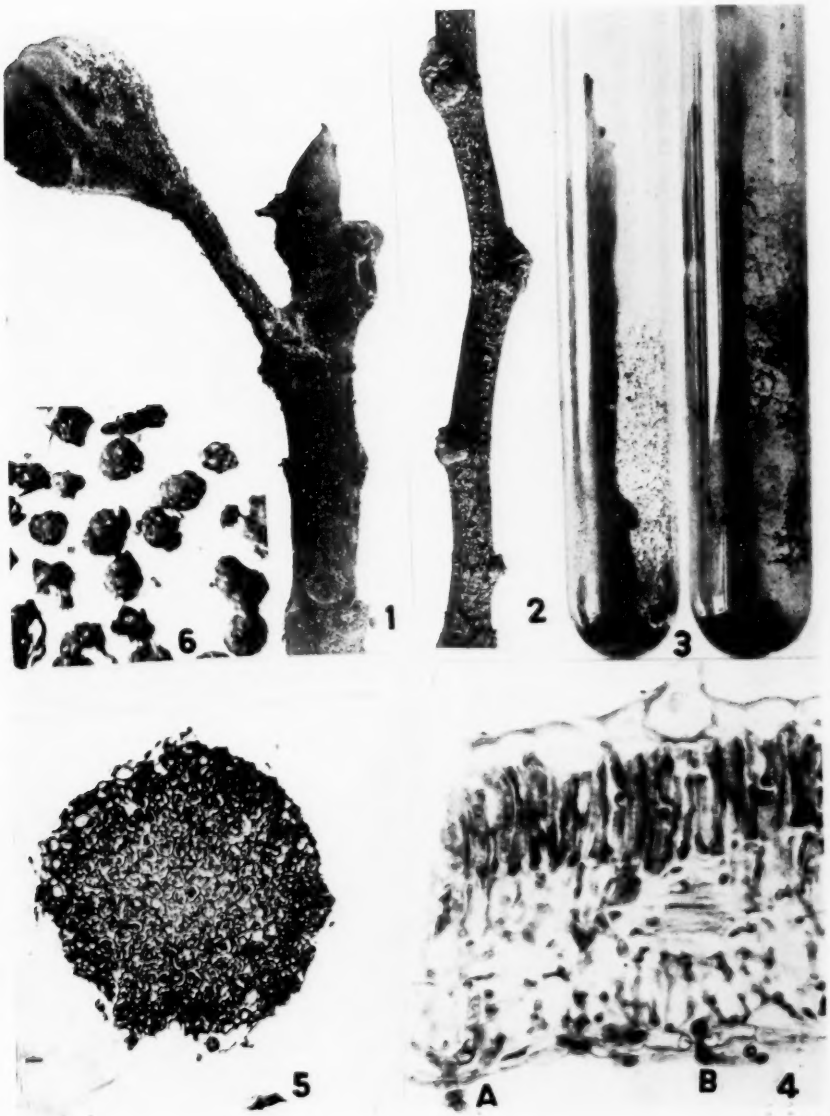
Fig. 2. Fig twig defoliated by the fungus. Numerous sclerotia are accumulated on one side of the twig. × 1.5.

FIG. 3. Three-weeks-old cultures on sterilized bean pods. R. microsclerotia on left, R. Solani Kühn on right.

FIG. 4. Cross section of diseased fig leaf showing penetration of mycelium through stomata at *a* and *b*.

FIG. 5. Section through a sclerotium of R. microsclerotia.

FIG. 6. Sclerotia from a fig branch. × 25.



MATZ: RHIZOCTONIA OF FIG

BUCKEYE ROT OF TOMATO FRUIT

C. D. Sherbakoff

With Five Figures in the Text

A hitherto undescribed rot of tomato fruit has been under the writer's study since January, 1915, and while there are still many phases of the disease which have to be determined by further work, nevertheless certain important facts have been determined and these findings may be of some use to those who are interested in tomato culture and diseases.

SYMPTOMS

The disease occurs only on the fruit of the tomato on which it appears in the form of a grayish, or pale to dark greenish brown, often distinctly

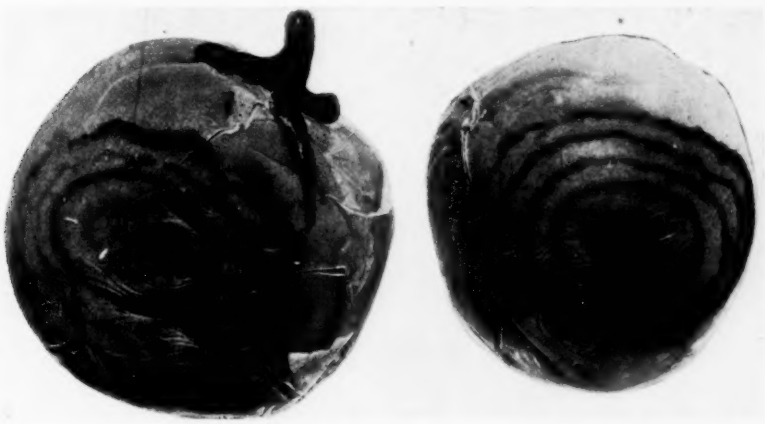


Fig. 1. Buckeye Rot of Tomato

These fruits show the most striking symptoms of the rot. Often the zonation is indistinct and sometimes entirely lacking. These fruits were preserved in formaldehyde for nearly two years. Natural size.

zonate rot (fig. 1). The affected parts of the fruit retain their normal shape. The consistency of the rot is much the same as that of the normal fruit—hard when the fruit is green and somewhat soft when it is mature. In the field the surface of the rot on green fruits is smooth and without

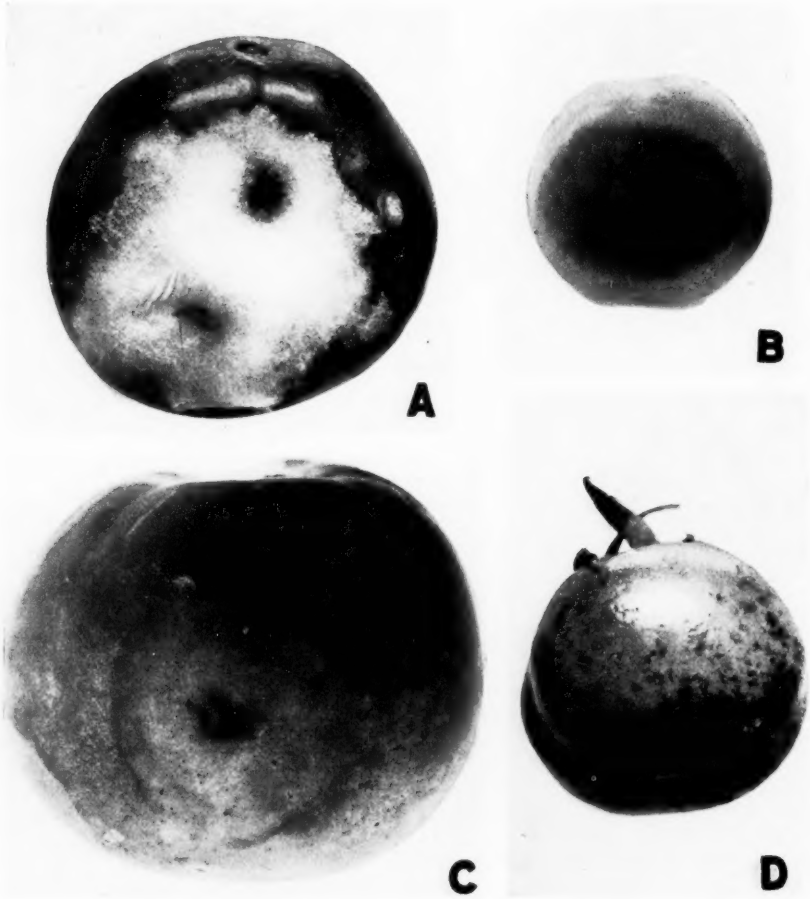


FIG. 2. TOMATO FRUITS INOCULATED WITH PHYTOPHTHORA TERRESTRIA

A, the fruit was kept in a moist chamber for ten days before the photograph was taken; under those conditions an abundant aerial mycelium is produced by the fungus. Natural size. B, green fruit inoculated from pure culture and kept one day in a moist chamber and then four days in open air before the photograph was taken; no aerial mycelium is produced under these conditions. × .75. *C*, a ripe fruit seven days after inoculation showing the rot produced by inoculation with swarm-spores; the dark spot is at the centre of the lesion; the affected area is 3.5 centimeters in diameter but is so near the color of the normal fruit that it does not appear distinctly in the photograph. Natural size. *D*, a green fruit, three days after inoculation with swarm-spores; the numerous infections appear in the form of minute, dark, scabby specks on the surface of the fruit. × .75.

any fungal growth. When the affected fruit is kept in an enclosure with high humidity, especially when the fruit approaches maturity, the fungus which causes the rot may be observed commonly on its surface (fig. 2*A*).

The rot occurs on the fruit in all stages of its development, beginning almost invariably at the point where the fruit touches the ground. Naturally, the fruit touches the ground most commonly with the blossom-end, on which account this rot often appears as a peculiar form of blossom-end rot and for which it sometimes has been mistaken.

NAME

The disease is known among some of the growers on the East Coast as water logged fruit. This name cannot be adopted for the rot because it is misleading and because it has no other advantage in its use. The name brown rot though it would often describe the disease, ought not be used in reference to the disease, first, because there are even more frequent cases when the color of the rot is not distinctly brown, and second, because the name has been applied already by Bancroft to an apparently different rot of tomato fruit.

Some of the tomato buyers use the name buckeye, in reference to a rot of tomato fruit. The writer was unsuccessful in finding with certainty what particular rot is called by that name, but his indirect information and observations indicate that the name refers to the rot under consideration. This name describes very well the most striking feature of the lesion on fruit affected with the disease, namely, its broad zonation, in which case the lesion indeed much suggests the eye of a large animal. The name also has not been used in literature before in reference to any disease of a similar nature. Therefore, it is suggested that the common name, buckeye, should be used in reference to the tomato fruit rot described here.

OCCURRENCE

The rot was found by the writer for the first time in January, 1915, at Goulds, Florida. Soon after the first observation and during the following three months it was found in every tomato field of that locality on the prairies—low marl lands usually under water during rainy summer months. The whole district is known as Redlands and lies at the extreme south end of the Florida East Coast, namely, south of Miami.

The same rot was observed by the writer in 1916 on the West Coast also. In April of that year it was found in a field near Bradentown, and in May in a shipment of tomato fruit received by the writer from a field near Palmetto. In both instances the tomatoes were grown on the common low hammock land of that vicinity.

The writer also found among some old specimens of tomato fruit preserved in formalin and kept in the laboratory at Gainesville, two specimens which by external symptoms and microscopic examination proved to be affected with this same rot. One of the specimens had a label indicating that it came from Little River, near Miami, in 1911. The other specimen bore no label.

All these observations show that the rot occurs in South Florida on both coasts where it is common in low fields even during a comparatively dry season, such as that of 1916. No actual observations were made of its occurrence in other parts of the state, but judging from its common presence in so widely separated parts as the east and west coasts and on soils so different in character, one might safely assume that it is much more generally distributed than observations indicate.

HISTORY

The preserved specimen of the rot found in the laboratory and previously mentioned, shows that the disease was present in the state at least as early as 1911. An inquiry among tomato growers of the East Coast also indicates that it has existed there a long time.

Pathological literature, with one exception, contains no reference to any disease of tomato fruit similar to the rot under consideration here. The organism which causes this rot is closely related to *Phytophthora infestans* but the latter fungus is not the same as the one which causes the rot herein described and the disease produced by *P. infestans* is also different because it affects all aerial parts of the plant and the fungus always produces abundant conidia on the surface of the affected parts of the fruit.

The previously mentioned exception is a short note by Bancroft[1] on The Brown Rot of the Tomato, in which is described briefly the symptoms, occurrence, economic importance, and the method of transmission of the disease. No illustrations of any kind accompany the article to assist in identification of the disease and in general it is too brief to judge with certainty whether the tomato fruit rot reported from England is the same as, or different from the rot found in Florida. It appears that the rot of tomato fruit reported by Bancroft has these two features similar to the buckeye rot: (1) The disease occurs only on the fruit; (2) the fungus associated with the rot in England is closely related to the fungus which causes the rot in Florida.[2]

[1] Bancroft, C. K. The brown rot of tomato. Jour. Bd. Agr. (London) **16**: 1012. 1910.

[2] Whether it is really the same fungus or not it is impossible to determine, because about his fungus, Bancroft merely says "the tissues of the endosperm and embryo" of the affected seed "contain fungal hyphae, which from their characters

The points in which the two rots appear to differ are as follows: (1) In describing the rot in England, Bancroft says: "A fruit which is infected first shows discolored patches on its surface; these usually run together, so that the whole or almost the whole surface of the fruit becomes discolored." The rot observed in Florida as a rule appears in form of one, rarely more, gradually spreading, often distinctly zonate spot, usually at the blossom end of the fruit; (2) Bancroft from all his observations on the rot says this in regard to the way in which the disease affects the fruit: "This infected seed . . . . is known among the growers to be capable of germinating and is reported to produce plants which always bear infected fruits. These facts, coupled with the results of microscopic examination of the seed, suggest that the hyphae may be capable of existing in the seed in a resting condition, becoming active when the seed germinates, and keeping pace with the growth of the plant until the fruit is formed." That is, Bancroft evidently records no other method of infection of the fruit than the one suggested in the above citation, while it is evident that in the case of the rot in Florida the infection starts from outside the fruit. From the above citation it is also evident that the rot reported by Bancroft is associated rather with the use of infected seed (the plants from infected seed "always bear infected fruits") while in our case it evidently is associated with the infested soil, and only the fruits which touch or nearly touch the ground are affected with the rot.

On the whole, it seems that the disease described by Bancroft is different from the rot of tomato fruit found in Florida, and the latter should therefore be considered as a new one to the literature.

ECONOMIC IMPORTANCE

The data at hand will not justify any precise statement concerning the extent of damage caused by the rot. But considering that the tomato crop is the most important of all vegetable crops in Florida, and considering also that the rot was actually observed to affect up to fifteen per cent of the fruit in the field and up to ten per cent of the fruit in transit, it is evident that the disease is important.

CAUSE

Repeated isolations from the tissues of tomato fruit affected with the rot invariably yielded one and the same fungus, usually in pure cultures di-

appear to be hyphae of *Phytophthora omnivora*." Hyphae of a number of fungi belonging to the same family do appear under similar conditions alike, the fungus causing the rot in Florida included; and yet they are quite different, but to differentiate them much more than appearance of the hyphae is needed.

rectly from plantings. The first isolations were made from the material collected on the East Coast in January, 1915; the last in May, 1916, from material obtained from the West Coast.

The isolations were made by planting small bits of the affected tissues (from under the epidermis and after the fruit was disinfected in mercuric chloride solution, 1 : 1000, for about fifteen minutes) into either petri dishes with a suitable medium (corn-meal and oat agars were most commonly used for this purpose) or into test-tubes with sterilized bean pods or oat agar. Dilutions of swarm-spores were employed to make certain that the cultures were pure. This was an easy procedure because the fungus readily sporulates and the swarm-spores are produced from mature conidia (swarmsporangia) in a very short time and practically under all conditions of the laboratory (under favorable conditions swarm-spores were produced in some instances eight minutes after the culture was placed in fresh water). A very successful procedure here is to place a good-sized piece of bean-pod culture (two or more weeks old) of the fungus into a sterilized watch-glass, with a few cubic centimeters of sterilized water in it, for about forty-eight hours; then, after the culture in the watch-glass is washed a few times in fresh sterilized water, it is left in the watch-glass with a few cubic centimeters of water for half an hour. In the first two days the bean-pod culture usually produces a great mass of conidia; in half an hour or an hour after it is rinsed, these swarmsporangia will liberate into the water a considerable number of swarm-spores; this water with numerous swarm-spores in it is to be used then for poured-plate dilutions made in the ordinary way. Corn-meal agar was commonly and successfully used by the writer for these dilutions.

Inoculations of tomato fruit, detached from the plant, and not detached, and of all stages—from very young to red-ripe—with pure cultures of the fungus, invariably resulted in reproduction of the rot (fig. 2). The inoculations were made by placing small bits of the culture and water suspensions of swarm-spores upon wounded and unwounded surfaces of the fruit. In the case of swarm-spore inoculation a piece of the fungus culture was dropped into a large jar nearly full of sterilized water and then the fruit was placed into the water. Detached tomato fruits float in water and undetached fruit can be conveniently placed in such a way that only a part of it will be in the water.

Inoculations into wounded fruit nearly always showed the rot in twenty-four hours. Inoculations into unwounded fruit, whether mycelium or swarm-spores were employed, sometimes showed the rot in twenty-four hours after the inoculation was made, but often the infection could not be detected until three or even four days later. At present no explanation is offered for this variation in the incubation period.

Repeated reisolations were made from artificially infected fruit. These uniformly yielded again the same fungus, leaving no doubt that this fungus is the cause of the buckeye rot here described.

THE FUNGUS

The fungus which causes the buckeye rot of tomato fruit has all the characters—the formation of swarm-spores within the conidium and their escape individually or in groups included—of the genus Phytophthora and therefore should be classed with members of that genus in spite of its soil habitat (fig. 5).

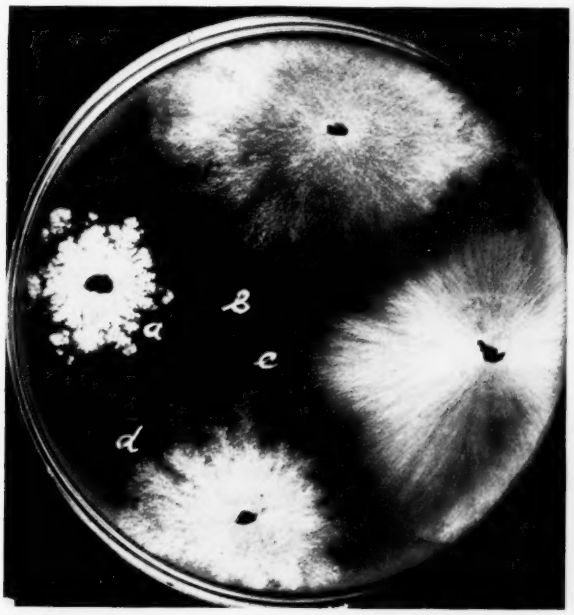


FIG. 3

FIG. 3. CULTURES OF P. TERRESTRIA AND RELATED SPECIES

The medium is corn-meal agar, age twelve days, natural size. The characteristic tufted growth of P. terrestria on this medium is markedly different from that of related species. *a*, Phytophthora terrestria; *b*, Phytophthora erythroseptica; *c*, Phthiacystis citrophthora; *d*, Phytophthora cactorum.

FIG. 4

FIG. 4. SEXUAL ORGANS OF PHYTOPHTHORA TERRESTRIA

A fertilized oogonium with antheridium at the base. The stalk of the oogonium evidently penetrates the antheridium. From four-months-old culture on steamed bean pod. × 1240.

The fungus has been grown and studied on various media parallel with other organisms related to it, such as *Pythium debaryanum* Hesse., *Pythiacystis citrophthora* Sm. & Sm., and several species of Phytophthora, *P. cactorum* (Lebert & Cohn) Schr. and *P. erythroseptica* Pethybr. included. This comparative study shows plainly that the fungus causing the buckeye rot of tomato fruit is different from the others. Its peculiar tufted growth on the corn-meal agar[3] in plates, is one of the differentiating characters, especially valuable for an easy separation of this fungus from the others (fig. 3).

Examination of the literature also indicates that this fungus has not been previously described. However, evidently the same organism wa isolated before, though from another host; but it has been considered to be the same as the fungus of the lemon brown rot, namely, *Pythiacystis citrophthora* Sm. & Sm. The reference here is made to the organism isolated by H. S. Fawcett[4] and by H. E. Stevens from the bark of citrus trees in Florida affected with the foot rot.

The writer's comparative study of the fungus of the buckeye rot of tomato, of the fungus of the lemon brown rot, *P. citrophthora*, and of the fungus from the citrous foot rot in Florida shows that the tomato rot organism and the one of the citrous foot rot are morphologically and culturally identical and that it is distinctly different from the true *P. citrophthora*.

A fungus was recently isolated by the writer from a lupine stem rot which is evidently the same as the one of the buckeye rot of tomato fruit.

Inoculations of tomato, sweet pepper, watermelon fruit, of lemons and of tubers of Irish potatoes with pure cultures of the several species of Phytophthora, previously mentioned, of the Pythium, Pythiacystis and three strains of the fungus of the buckeye rot, including one strain isolated by H. E. Stevens from diseased bark of a citrus tree in Florida affected with the foot rot, show that certain organisms distinctly different in their morphology may affect the same host and produce more or less similar effects. The fungus of the buckeye rot produced a rot of all the parts of the plants here referred to.

These inoculations thus indicate that the organisms which do attack the same plant or plants cannot on this basis alone be considered identical with each other.

[3] The corn-meal agar is made by heating 50 grams of corn-meal in 1000 cc. of distilled water at 60°C. for an hour, then filtering the liquid through a filter paper, adding to it 15 grams of agar and the required amount of distilled water to bring volume of the liquid to 1000 cc., cooking the substance in a double boiler until all agar is dissolved, cooling down to 50°C., adding the white of an egg, autoclaving at 15 pounds of pressure for about fifteen minutes, filtering through a filter paper, tubing and autoclaving as before.

[4] Fawcett, H. S. The known distribution of Pythiacystis citrophthora and its probable relation to mal di gomma of citrus. Phytopath. **5**: 66, 67. 1915.

On the basis of the data obtained in the course of the writer's comparative study of the fungus of the rot of tomato fruit and of the other fungi related to it, it is considered an undescribed species which may be briefly characterized as follows:

Phytophthora terrestria n. sp.

Mycelium at first continuous then septate; conidia usually terminal, sometimes intercalary, mostly oval, papillate at apex but variable, 42.5 × 30.5 (36–46 × 24–35)μ, germinating mostly by swarm-spores; swarm-spores asymmetric, with two cilia on one side, 9.5 (9–11)μ, when in resting, globoid stage; chlamydospores common, mostly globose, 34 (30–40)μ; oogonia common in old cultures on steamed bean pods, globose, 22 (19–24)μ with the stalk evidently penetrating through large, nearly globose antheridium (fig. 4); oospores globose, 20 (18–21)μ; colonies on corn-meal agar, in petri dish, peculiarly tufted.

Hab. Parasitic in tomato fruit causing buckeye rot, in bark of trunks of citrus trees causing foot rot, in stems of a Lupine causing stem rot, and apparently in low soils; in Florida.

Phytophthora terrestria sp. nov.

Mycelio priuo continuo deinde septato; conidiis fere terminalibus aliquando intercalaribus, plerumque ovoideis apice papillatis sed valde variabilibus, 42.5 × 30.5 (36–46 × 24–35)μ, per zoosporos fere germinatis; zoosporis asymmetris, lateraliter 2-ciliatis, 9.5 (9–11)μ diam. quum quieti, globosi statu; chlamydosporis vulgaribus, plerumque globosibus, 34 (30–40)μ diam.; oogoniis globosis, 22 (19–24)μ diam., radicibus per amplum sub-globosum antheridium aperte penetrantibus; oosporis globosibus 20 (18–21)μ diam.; coloniis in agaro Zeae Maydis farina, in petri patera, suo genere cristati.

Hab. parasitice in fructibus Lycopercici esculenti efficiens "buckeye rot," in trucis Citri efficiens "foot rot," in caulibus Lupini sp. efficiens "stem rot," et aperte in humilibus solis, Floridensibus, Am. bor.

CONTROL

No direct control experiments with the buckeye rot have been conducted, but the fact that the rot occurs almost invariably only when the fruit touches the ground, or is very close to it, naturally suggests staking the tomato plants to prevent it. The staking would hold the fruit high enough above the ground to keep it from attack by the fungus.

The fact that the fungus attacks the fruit from the ground, coupled with the fact that the rot, once it starts, progresses under normal conditions fairly rapidly (often nearly the entire fruit may become affected in

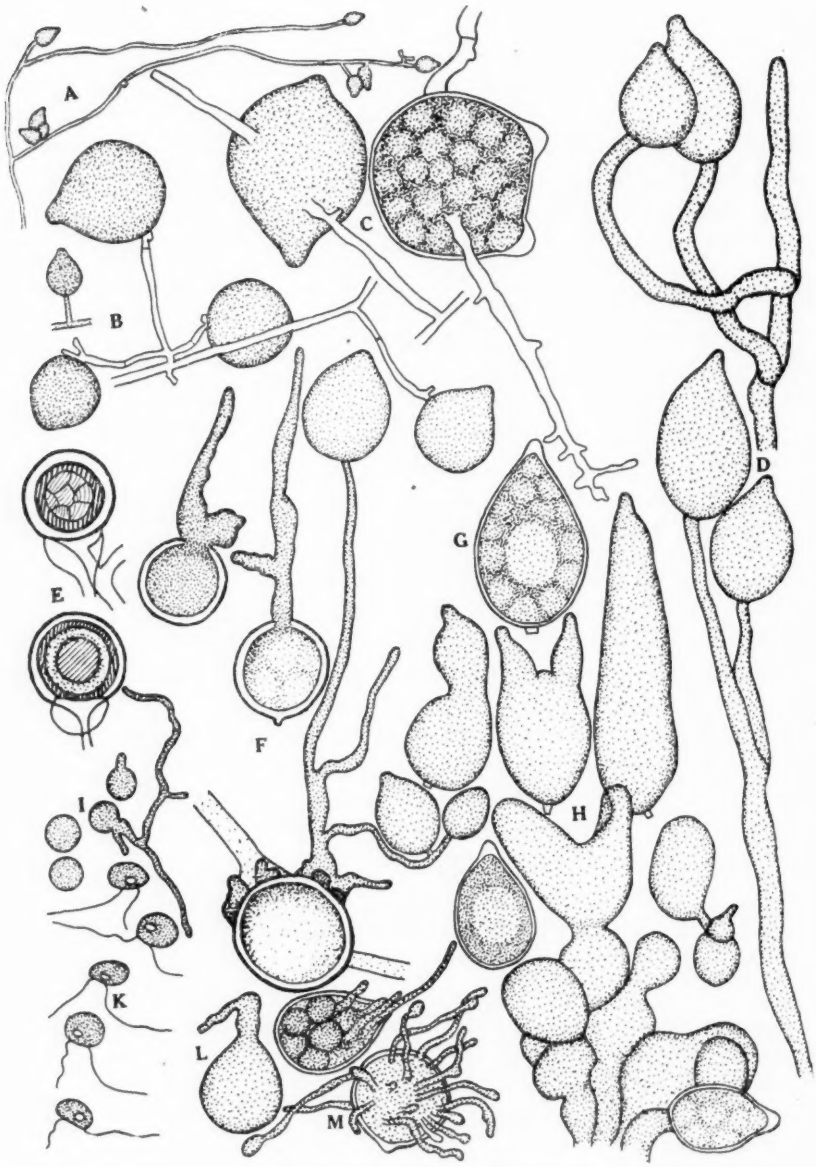


FIG. 5. PHYTOPHTHORA TERRESTRIA

three days after inoculation, the rate depending evidently on the temperature, moisture content, and maturity of the fruit), also suggests a method of control of the rot while in transit. Here it probably would be very advantageous to keep the fruit for a few days after it is picked before packing it for shipment. All fruits that were infected in the field would develop the rot sufficiently to be detected by the packers and thus be thrown out without contaminating the rest of the fruit, which then could be safely packed and shipped. But the practicability of these methods has not been tested.

SUMMARY

1. The buckeye rot of tomato fruit is common in certain places on the low lands of the east and west coasts of Florida.

2. It occurs only on the fruit that touches or nearly touches the ground.

3. It is caused by the fungus *Phytophthora terrestria* n. sp., which is also found on other hosts.

4 It causes considerable injury to the fruit in the field and in transit.

5. Staking of the plants in the field and keeping over the picked fruit a few days before it is packed seem to be practical methods of its control.

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EXPLANATION OF FIG. 5

A, conidiophores from culture on hard, oat agar, eight days old. × 100. *B*, conidiophores and *C*, intercalary conidia; from the same medium and of the same age as *A*. *D*, conidiophores from the fungous growth on an artificially inoculated (upper) and on naturally (lower) affected and nearly mature tomato fruit. *E*, oospores within the oogonia with the basal antheridia evidently penetrated by oogonial stalk. *F*, germinated chlamydospores. *G*, typical and *H*, various abnormal forms of conidia, produced on surface of a mature tomato fruit affected with the buckeye rot. *I*, resting and germinating swarm-spores. *K*, motile swarm-spores (fixed in Flemming's fluid and stained with eosin). *L*, conidium germinating by a single germ tube. *M*, two conidia germinating by many germ tubes (evidently each swarm-spore which did not escape gives its own germ tube). *B*–*L* × 500.

NOTEWORTHY PORTO RICAN PLANT DISEASES

F. L. Stevens

The following diseases are of interest to pathologists of the United States, either because they are new, or because they are little known diseases of important crops belonging within the territory of the United States or are caused by fungi of special interest for one reason or another.

Coffee. *Pellicularia koleroga.* This fungus occurs in great abundance, especially in the lower altitudes in Porto Rico. In destructiveness and general appearance it gives an impression somewhat like that of pear blight with many branches killed and the dead leaves matted and hanging by their fungous attachments. The fungus forms thin skin-like membranes over the lower leaf surfaces and has thread-like growths leading down the petiole and adjacent branches. In habit it strongly resembles *Hypochnus ochroleucus* Noack as it occurs on apples in the Carolina mountains, and the writer long has had the suspicion that the two fungi are related.

Hemileia vastatrix. This destructive fungus, though not seen in Porto Rico, is worthy of mention on that account. There is a report that it was imported into the island, almost immediately recognized, and due to the vigilance of the experiment station officials was so thoroughly eradicated that not a specimen has since been collected. The following quotation from a letter from Mr. May, in charge of the Porto Rican Experiment Station, is worthy of record.

"When the station was first established in Porto Rico we were carrying on some experiments in the Carmelita coffee plantation, five hours by horseback above Ponce, under charge of J. W. Van Leenhoff. In 1902 or 1903, I do not remember which, it was before I came to the station, Van Leenhoff got some little coffee trees from a Dutch warship that brought them from Java. After he planted them out he noticed that they had what appeared to be *Hemileia vastatrix.* Mr. Van Leenhoff had been a coffee planter in Java and was pretty sure of the fungus from such investigation as he could make. The matter was communicated to Washington and L. A. Clinton, of Connecticut, was sent down to investigate the trouble. In the meantime Van Leenhoff took every precaution, destroying all the plants and all material that might have in any way been connected with them. Clinton spent some weeks at the Car-

melita but could find no traces of the fungus and as none has appeared since, Van Leenhoff doubtless made a 'clean up.' Since that time great care has been exercised with all coffees brought from foreign countries."

Stilbella flavida. The characteristic circular leaf spot caused by this fungus is common in the higher altitudes, but is never found in low regions. The fungus is of unusual scientific interest on account of its problematic relationships. It is by no means limited to coffee but is found on numerous hosts.

SUGAR CANE. *Leptosphæria Sacchari.* This fungus is quite commonly present as a destructive leaf spot.

PALM. *Graphiola Phoenicis.* This fungus, which is of uncertain relationship and is common as a minor pest in northern greenhouses, is found in the open on several species of palms in Porto Rico. It has been noted particularly upon the date palm and the hat palm. The hat palm is a very profitable plant, a single leaf being worth about ten cents. Frequently trees are seen with all the leaves closely covered with Graphiola and lines of diseased tissue reaching long distances through the petioles. The financial damage is done to the young, as yet unfolded leaves, the fungus penetrating them and rendering them worthless.

Meliola furcata. This is present sometimes to such extent as to largely cover the leaves with its black coating. It has not been observed on cultivated palms but occurs in great abundance on wild *Thrinax ponceana* on plants of marketable size. As yet, however, there seems to have been no attempt to make a commercial enterprise of shipping the beautiful young palms which spring up spontaneously in such profusion in Porto Rico.

Auerswaldia palmicola. This was noted only a few times, but in those instances affected nearly every leaf and leaf-segment on the tree.

BREAD FRUIT. *Uredo Artocarpi.* The immense leaves of the bread-fruit harbor numerous fungi. The crop, if it can be called such, is not of high value, and this rust, though interesting, is not of much economic significance.

CORN. *Phyllachora graminis.* Mention has been made of this in PHYTOPATHOLOGY by Miss Nora Dalby. The disease was wide-spread in Porto Rico and must have been to considerable extent injurious.

BEAN. *Dimerium grammodes.* This striking fungus which occupies and covers the veins of the affected parts of the leaf with its conspicuous black perithecia is common on several genera of legumes, among them cultivated beans.

GUAVA. *Meliola Psidii.* The black spots of this fungus are almost universally present wherever the host is found. There is but little, if any injury.

Aschersonia. What is taken to be one of this genus sometimes occurs profusely on the lower surfaces of guava leaves, giving them a livid scarlet color, conspicuous to a considerable distance. The fungus appears to be growing upon a scale insect, probably *Alerodes citri*.

Cephaleurus virescens. This algal parasite is of special interest. The spots show well from both below and above the leaf, the leaf tissue being killed. This alga, also widely known as the cause of a serious tea disease, is present parasitically on a large number of Porto Rican plants.

GONDULE. *Uromyces dolicholi*. This universally present leguminous plant is almost always rusted to a slight degree, sometimes badly rusted.

MANGO. *Meliola Mangiferæ*. Meliola is very common and widespread but apparently not injurious. *Gloeosporium mangiferæ* is often abundant and injurious, especially upon the fruits of the finer varieties of the mango. The effect in general is much like that of the bitter rot on apple.

SWEET POTATO. *Coleosporium Ipomœæ*. Rust is common on this and other Ipomœas, but usually not to serious extent. In one field at Preston's Ranche near Naguaba, infection was general and serious. Each sorus was also parasitized by a Fusarium-like fungus, rendering it white.

GRAPE. *Physopella vitis*. This is a rust of cultivated grape. Three collections were made in Porto Rico but all from the same vines, namely, at Patillo Springs. The rust was present in quantity sufficient to make it injurious. The writer knows of only a few grape vines in Porto Rico. If there were more vines perhaps there would have been more collections of this rust.

PEANUT. *Uromyces arachidis*. Only one collection of this rust was made. Indeed, the peanut plant is not very common in Porto Rico.

CANNA. *Puccinia Cannæ*. The rust on Canna is common on both wide and cultivated Cannas in all parts of Porto Rico; on nearly every one of the host plants. Sometimes the rust is so abundant as to appear fairly destructive.

INGA LAURINA. *Microstroma* sp. This host, an important leguminous coffee shade tree, is frequently much infested with an undescribed Microstroma which causes large witches brooms.

PITHECOLOBIUM SAMAN. *Microstroma* sp. This leguminous tree is being introduced into Porto Rico through the efforts of the experiment station, and in the seed beds and propagating beds it is frequently heavily infested with an apparently undescribed species of Microstroma.

PASPALUM. *Myriogenospora* sp. The Paspalums of yard and pasture often bear this very interesting fungus. Infection is usually general throughout the plant, that is, if one part is infected each leaf is likely to be invaded.

MELIA. *Pseudoperonospora* sp. Two collections were made, in widely separated parts of the island, of this fungus. The damage is probably slight. The four fungi last mentioned will be described fully by Dr. Lamkey.

FICUS. *Kuehneola Fici*. This rust was very conspicuous and present on a large number of species of this genus. Certain large trees at the proper period of the year were repeatedly covered with the rust and often small shoots a foot or so high would have each leaf completely rusted.

COTTON. *Kuehneola Gossypii*. Very little cotton is raised in Porto Rico. This rust was found in considerable abundance in one field, though probably not doing much damage.

MANIHOT. *Uromyces Janiphæ*. Only one collection of this rust was made in Porto Rico, though the host is very common there under cultivation, and the rust has been looked for repeatedly.

SOOTY MOLDS. The sooty molds familiar to Northern pathologists on the orange and Camellia and to lesser degree on many greenhouse plants, abound in Porto Rico. There seems to be no specialization to hosts and they grow indiscriminately upon all hosts. If it be a large plant as a mango tree that is primarily infected, the fungus, spread doubtless by rain, is found growing upon every kind of plant beneath the tree. Very little evil effect is noticeable other than the unsightly condition produced. The statement is frequently seen that these sooty molds exist upon insects or insect secretions. Such organic matter certainly favors them and increases their luxuriance, but the sooty molds are not entirely dependent upon insects and insect products and may abound without them.

While many of the Porto Rican sooty molds are much like, perhaps quite like, the sooty mold of the orange, other sooty molds diverge more or less from this in character, yet show similarity enough among themselves to allow them to be classed in the same group.

The writer has so far refrained from using latin names for these fungi. The orange and camellia sooty molds are best known under the generic name Meliola, and the generic conception of Meliola was broad enough to receive them until about 1892. Gaillard's monograph of Meliola then showed that these forms clearly differ greatly from the typical Meliolas in essential details, and he excluded from Meliola the tropical sooty molds. Today any student of Meliola would, I think, agree with him. Meliola with its capitate and mucronate hyphopodia, its characteristic mycelium, perithecia, asci and spores constitutes a well-defined genus from which the sooty molds with their bead-like mycelium, peculiarly shaped pycnidia and perithecia differ widely. The fact that they should

be excluded from Meliola is clear. Just where they should be placed is, however, not so clear. They comprise a rather well-defined group which in Porto Rico certainly consists of a large number of species on many hosts. This group perhaps coincides in limits with what Saccardo in his earlier volumes calls the sub-family Capnodieæ and which he in his fourteenth volume calls a tribe. This tribe is not recognized by Lindau in the Naturlichen Pflanzenfamilien, but is included in the Perisporiaceæ. Clements gives the Capnodiaceæ family rank. Arnaud in 1911 in his monograph "Contribution a l'etude des Fumagines" Ann. Ec. Nat. Agr. Montpellier, places them for convenience in the "Spheriacees dictyosporees." Many writers today place the better-known of these forms of the habit of the old *Meliola Citri*, *Meliola Camellæ*, and so forth, in the genus Capnodium. Thus we have *C. stellatum*, *C. Mangiferum*, *C. Coffeæ*, *C. brasiliense*, *C. footie*. Others place these forms in the genera Pleosphæria, Antennaria, Apiosporium, and so on. It is not the present purpose of the writer to attempt to determine the generic limits here or the status of these species, but rather to call attention to the rich mass of material occurring in the tropics, which may well be called the Sooty Molds and in the main belong to the Capnodieæ of Saccardo.

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PYCNIAL STAGES OF IMPORTANT FOREST TREE RUSTS

JAMES R. WEIR AND ERNEST E. HUBERT

WITH TWO FIGURES IN THE TEXT

The discovery on September 29, 1916, at Darby, and on October 8, 1916, at Bonner, Montana, of abundant exudations of pycnospores on swellings of *Pinus ponderosa* (fig. 1) and *Pinus contorta* caused by *Cronartium Comandræ* Pk. somewhat alters the impression that the pycnia of the caulicolous species of forest tree rusts appear only during the spring or early summer months. This unusual appearance of pycnospores seems to be of sufficient importance in the life history of this rust to be reported at this time together with further facts concerning the pycnial stages of *Cronartium coleosporoides* (D. & H.) Arthur,[1] *Cronartium Comptoniæ*,[1] Arthur *and Cronartium cerebrum* (Pk.) H. & L. Spaulding[2] in his accounts of the white pine blister rust (*Cronartium ribicola* Fisher) states that the pycnial stage may be found early in the spring or at almost any season in late summer or fall, he having found them on the hosts in November within a month after placing in the greenhouse. The collections of *Cronartium Comandræ* on *Pinus ponderosa* and *P. contorta* bearing the pycnial stage were of the spindle-shaped type of swellings and bore in the central portion cankerous corrugations of the current season's (May, 1916) aecial eruptions. The pycnial drops appeared on the freshly swollen areas at either end of the spindle-shaped hypertrophies bordering the ruptured areas. This conforms to observations made on a collection of the pycnial drops made near Bonner, Montana, on May 22, 1916, from lesions of *Cronartium Comandræ* on *Pinus ponderosa*. The pycnial exudations, consisting of a clear, sticky, sweet liquid with a large number of minutely pyriform spores in suspension, appear as large or small drops issuing from minute blister-like swellings in the epidermis of the infected tissues. Measurements of the pycnospores of the various collections made agree closely with those made by Boyce,[3] (50) 3 to 4 μ by

[1] Weir, J. R. and Hubert, E. E. Recent cultures of forest tree rusts. Phytopath. **7**: 106–109. 1917.

[2] Spaulding, Perley. The blister rust of white pine. U. S. Dept. Agr. Bur. Plant Ind. Bul. 206: 27–28. 1911.

———. The white pine blister rust. U. S. Dept. Agr. Farmer's Bul. 742: 12. 1906.

[3] Boyce, J. S. Pycnia of Cronartium pyriforme. Phytopath. **6**: 446–447. D. 1916.

3 to 7 μ (3 by 4). They are characteristically pyriform, of a pale turtle green color[4] issuing from minute openings in the epidermis and are produced from subepidermal pycnial stromata of irregular outline. Boyce states that the pycnospores are hyaline. An examination of both isolated and massed spores indicates that they are colored, though faintly.

The pycnial stages of *Cronartium coleosporoides* and *Cronartium Comptoniæ* have, up to the present, remained unknown. Mention of the discovery of the stage has been made in a previous report[5] but details were not given at that time. In the period from April 4 to 15, 1916, abundant pycnial exudations containing pycnospores were obtained from galls of *Cronartium coleosporoides* (fig. 2) on *Pinus ponderosa* and *P. contorta*. These pycnial drops were found in the field and were also forced in the laboratory at a much earlier date than produced in nature.[6] Out of a total of 32 galls, 28 produced pycnia by the forcing process, several of these later producing aecia. The pycnia of *Cronartium coleosporoides* on galls develop similarly to those of *Cronartium Comandræ* with one marked difference, that is, their appearance on old galls and lesions. The pycnospores of *Cronartium Comandræ* apparently develop but once on the same tissue preceding the appearance of the aeciospores. The production of aecia kills the infected tissues which are included in the aecial ruptures. The tissues bordering this area are invaded by the mycelium of the fungus, produce swellings, and give rise to pycnospores, either in early spring or in late summer and fall, whenever sufficient time has elapsed from the last production of aecia. In the cases recorded the pycnospores appeared in the same season following the production of aecia, with only five months intervening, but not from the identical area from which the pycnia were produced. In *Cronartium coleosporoides* the pycnospores are produced on old galls previously ruptured as well as on unruptured infected tissues. A description of the pycnia of *Cronartium coleosporoides* on galls follows:

Pycnial stroma in irregularly shaped areas, more or less scattered or anastomosing, caulicolous, subepidermal, forming minute, blister-like swellings when mature on unruptured infected tissues and issuing from cracks in the bark of old lesions; exuding a clear, sweet, sticky fluid in which the pycnospores are suspended forming drops of a cadmium yellow to orange color when first appearing, becoming clear as the spore mass settles to the lower end of drop, and orange to brick-red upon drying. Pycnospores hyaline, mostly spherical, occasionally ellipsoid or obovate. (50) 1.5 to 3.0 μ by 1.5 to 3.7 μ (2.5 by 2.5).

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[4] Ridgeway, Robert. Color standards and color nomenclature. Pl. 32. 1912.
[5] Phytopath. **7**: 106–109. 1917.
[6] The same.

Several specimens of *Cronartium Comptoniæ* bearing pycnial drops were secured by laboratory forcing methods following collection in the field. The material was collected on *Pinus banksiana* at Cass Lake, Minnesota, on May 12, 1916, placed in large test-tubes with water May 15, and developed pycnia on May 17 and 18. The pycnospores develop similarly to those of *Cronartium Comandræ* in respect to their appearance on pre-

FIG. 1. PYCNIAL EXUDATIONS OF CRONARTIUM COMANDRÆ ON LESION OF PINUS PONDEROSA

Note the large number of drops on the lesion

viously unruptured tissues. Here the aecial production also tends to kill the immediate tissue, in many cases girdling the stem. The following is a description of the pycnial stage of *Cronartium Comptoniæ*:

Pycnial stroma in irregularly shaped areas, more or less scattered or anastomosing, caulicolous, subepidermal, forming minute blister-like swellings when mature on unruptured infected tissues; exuding a clear, sweet, sticky fluid in which pycnospores are suspended forming drops of a cadmium yellow color when first

appearing, becoming clear as the spore mass settles to lower end of drops, and brazil-red upon drying. Pycnospores hyaline, ovoid to ellipsoid, very rarely pyriform. (50) 1.6 to 4.3 μ by 1.6 to 6.0 μ (2.2 by 4.0).

On May 12, 1916, a large collection of galls of *Cronartium cerebrum* (Pk.) H. & L. on *Pinus banksiana* were collected at Cass Lake, Minnesota. These were placed in large test-tubes with water in the laboratory

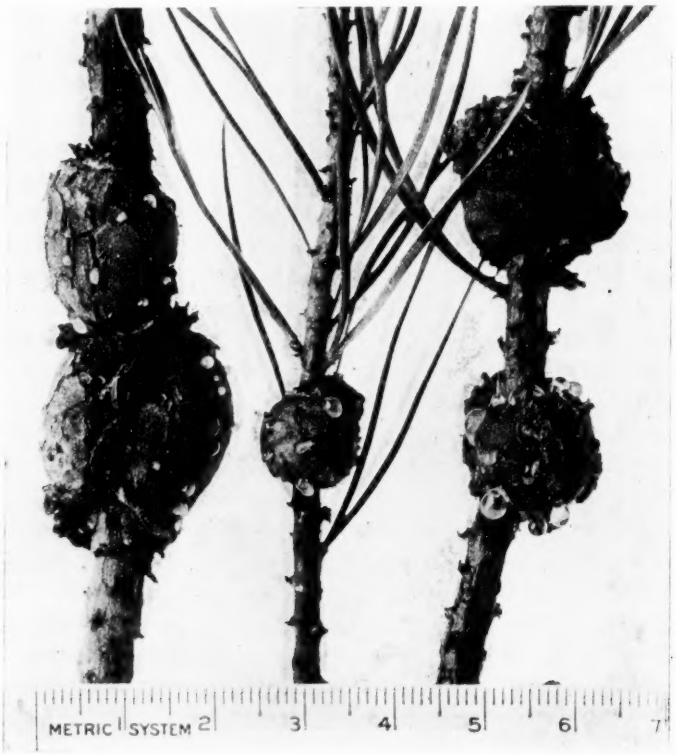

FIG. 2. PYCNIAL EXUDATIONS OF CRONARTIUM COLEOSPOROIDES ON GALLS OF PINUS CONTORTA

Note the settled spore masses in lower portion of drops

on May 15. Some of the galls bore pycnia when collected but the majority of pycnia appeared after forcing in the laboratory and continued producing pycnial drops up to May 17. On May 17, four of the galls developed aecia within four to five millimeter distance from the pycnial exudations on the same galls but not from identical pycnial areas. Out of twenty-eight galls, twenty-three produced pycnia in abundance and of these, eighteen also produced aecia. Several of the galls when received

from the field bore remnants of the pycnial exudations and at the same time were producing aecia in abundance. The pycnial drops when fresh have a slightly darker yel'ow color than those of *Cronartium coleosporoides*, and like the latter appear in the bark crevices of old galls as well as in minute blister-like swellings on the younger unruptured tissues of infected areas. When old and dried the pycnial exudations are difficult of detection on the surface of the infected tissues and have a brick-red color.

From observations made on *Cronartium coleosporoides* on galls both in the laboratory forcing experiments and in the field, it is determined that the aecia follow the pycnia in the same season, usual'y from eight to sixteen days apart but not appearing upon the identical areas. The galls shown in figure 1 were collected at Coeur d'Alene April 1, 1916, and were placed in test-tubes with water on April 3. From April 4 to 9 abundant pycnial drops were produced. From April 11 to 14 the galls began to show evidence of aecial eruptions and from April 16 to 17 aecia appeared. With a longer time-interval between the two stages this is what has been observed to occur in the field. Spaulding[7] has observed in the case of *Cronartium ribicola* that the pycnia precede the aecia by a short period.

A very interesting fungus frequently found during the past season in connection with the pycnial exudations and also found accompanying the aecial stage of the caulicolous rust is a species of Tuberculina which may be referred to *T. maxima* Rostrup.[8] This fungus was found attacking the pycnial and aecial stages of *Cronartium Comandræ* occurring on *Pinus ponderosa* and *P. contorta*, the pycnial and aecial stages of *Cronartium coleosporoides* on galls of *Pinus ponderosa* and *P. contorta*, and the pycnial and aecial stages of *Cronartium cerebrum* on *Pinus banksiana*. This species of Tuberculina attacks the stromatal layer as well as the fruiting bodies and erupts in powdery, lilac to nigrosin masses through the epidermis of the host tree. This fungus is considered by Tubeuf[9] to be of some economic importance although Lechmere[10] does not concur in this conclusion. The writers have not found it occurring in sufficient abundance to place any importance upon its economic possibilities.

OFFICE OF INVESTIGATIONS IN FOREST PATHOLOGY
BUREAU OF PLANT INDUSTRY
MISSOULA, MONTANA

[7] U. S. Dept. Agr., Bur. Plant Ind. Bul. 206: 27–28. 1911.

[8] Tubeuf, C. von. Ueber Tuberculina maxima, einen Parasiten des Weymouthskiefern-Blasenrostes. Biol. Abt. f. Land- u. Forstwirthschaft. **2**: 169. 1901.

[9] Tubeuf, C. von. Recent observations on the blister rust of Weymouth pine. Naturw. Ztschr. Forst.-u. Landw. **12**: 484–491. 1914.

[10] Lechmere, E. Tuberculina maxima, a parasite on the blister rust fungus of the Weymouth pine. Naturw. Ztschr. Forst.- u. Landw. **12**: 491–498. 1914.

REVIEWS

Edible and Poisonous Mushrooms. By W. A. Murrill, Assistant Director of the New York Botanical Garden. Handbook, 16mo., pp. 71, large colored chart, figs. 47. Published by the Garden. Price $2.

This work is primarily of interest to users of mushrooms. The chart contains very good illustrations of 30 species of edible mushrooms, and of 17 species of poisonous ones. A few of these are of interest to the forest pathologist, because they frequently attack the wood of living trees.

GEO. G. HEDGCOCK

PHYTOPATHOLOGICAL NOTES

New hosts for Razoumofskya americana and R. occidentalis abietina. *Razoumofskya americana* Nutt, has been previously reported on *Pinus contorta*, *P. banksiana*, *P. ponderosa*, and *P. jeffreyi*. On April 12, 1915, a specimen was received from J. E. Haefner of the Siskiyou National Forest, Oregon, on *Pinus attenuata*. On September 5, 1916, the writer collected both staminate and pistillate plants on *Pinus attenuata* in the Oregon Mountains, Siskiyou Forest. This indicates that the species may be expected to occur on any of the yellow pines. (See writer's note, Phytopath. **6:** 414. 1916.)

Razoumofskya occidentalis abietina (Engelm.) Coville, the large form on Abies, has been reported on *Abies concolor*, *A. grandis*, and *A. magnifica*.[1] During a trip on the Crater National Forest, Oregon, in September, 1916, the writer collected both staminate and pistillate plants on *Abies nobilis* and *A. amabilis*.

JAMES R. WEIR

Lightning injury to kale. In a previous article (Phytopath. **5:** 94. 1915) the writer, jointly with Gilbert, reported observations upon lightning killing of potatoes and cotton. As shown, the plants in the stricken zone die promptly over a somewhat circular area usually from one to three rods in diameter. Further evidence of this sort of injury in Wis-

[1] Hedgcock, G. G. Notes on some diseases of trees in our national forests. V. Phytopath. **5:** 176. 1915.

Wier, J. R. Mistletoe injury to conifers in the northwest. U. S. Dept. Agr. Bul. 360: 33. 1916.

consin potato fields has since come to us, also reports of like occurrence in sugar beet fields, although no example of the latter has come under our personal observation. It was of especial interest this summer to find a fully authenticated case of lightning injury to kale (fig. 1). This occurred on the trial grounds of D. M. Ferry & Company at Rochester, Michigan, about twenty-five miles northwest from Detroit. The lightning struck during the early part of a thunder storm, July 20,1916. The stricken spot was in the center of a bed of curly kale (*Brassica oleracea* var. *acephala*). Mr. Will Coulter, superintendent of the grounds, was

FIG. 1. LIGHTNING INJURY TO KALE

Note the white stake about the center of the dead area, marking the spot where the lightning struck.

walking a few rods away from this spot at the moment and was knocked to the ground, where he lay unconscious for a brief period. We visited the garden about September first, when Mr. Coulter kindly furnished us with the photograph of the field and the following data. Since he is a critical and trained observer, it may be accepted as accurate. "The white stake near the center of the bare area shows where the bolt actually struck. At this point there was made a nearly circular depression about 2.5 feet across and six to eight inches deep, and extending downward from the center of this depression as far as we could see was an irregular shaped hole about 2.5 inches in diameter. The kale plants at the time

of the storm were rather small and all had the appearance of having been struck by some strong force and flattened to the ground, and the three plants which seem to be inside the circle and have survived were almost completely covered with earth. The rest of the plants in the circle had a powder-burned appearance and all shrivelled up and disappeared within a week or ten days." The area as shown in the figure was roughly circular, about twenty to twenty-five feet in diameter. This accords closely in all respects with the effects of the lightning strokes as we have observed them in Wisconsin potato fields.

It is to be hoped that others may record, as they have opportunity, evidence of such injuries until we have a fuller understanding of these matters. From the evidence at hand, similar injuries may be expected with sugar and garden beets, and possibly carrots, with the various members of the cabbage-kale groups of vegetables, turnips, radishes, and so forth, and probably with the allies of the potato, such as tomato and egg plants. Special attention may also well be given to possible lightning injury of legumes in view of Sitensky's observations. (See Abstract, Zeitschr. Pflkr. **8:** 148, 1898), which have come to my attention since our former article. He reports a lighting stroke in a Bohemian alfalfa field when the plants were in blossom. The next day the plants were wilted down in a circular area about 5 meters across.

It is noteworthy that no case is recorded of like injury with any of the Gramineae, although it would seem that, since great areas are occupied by the grains and grasses in the northern states, lightning must often strike in such fields. When more evidence is at hand concerning the varying liability of such plants to injury in nature it will pave the way to some very interesting experimental work to determine the reasons why such variations occur. These may conceivably be associated with differences in the character or habit of aerial parts, with the character or distribution of the root systems, or with the relative electrical conductivity of the different plant tissues.

L. R. JONES

Puccinia glumarum. In May, 1915, the occurrence of *Puccinia glumarum* (Schmidt) Eriks. and Henn. was reported for the first time in the United States. It is so well known in Europe and certain Asiatic countries that its discovery at so many widely distant points in the western states led to considerable speculation as to time and method of introduction into America. Although we are still lacking definite information on these points, it is now definitely known that an examination of herbarium specimens at the New York Botanic Gardens indicates the fact that *P. glumarum* was collected in this country as long ago as June, 1892, when

C. V. Piper reported it as *P. rubigo-vera* on *Elymus americanus* and a month later as *P. rubigo-vera* on *Bromus hookerianus*, and distributed it under numbers 41 and 206. These specimens were found at Seattle and Everett, Washington, respectively.

Other American collections of *Puccinia glumarum*, made prior to 1915, were by E. T. and E. Bartholomew in August, 1913, at Billings, Mont., on *Hordeum jubatum* under number 4369; E. Bartholomew on *Hordeum jubatum* at Rock River, Wyo., in August, 1911, under numbers 1063 and 3763, and by A. O. Garrett in 1907 and 1909 in Utah and distributed as *P. rubigo-vera* under numbers 138, 191, and 192.

It would thus appear that *Puccinia glumarum* has been present in America at least twenty-five years and possibly longer.

H. B. HUMPHREY

Newton B. Pierce. The death is announced on October 13, 1916, at the age of sixty years, of Mr. Newton B. Pierce, formerly pathologist in the Bureau of Plant Industry.

Mr. Pierce in his early manhood was engaged in the lumber business, in partnership with his brother at Ludington, Mich. He was from a boy interested in natural history and spent a great deal of his time in the woods. At first he turned his attention to economic entomology, and very early developed into an excellent entomological artist. He was specially gifted in the field of draughtsmanship, particulary in the delineation of plants and insects. Desiring to advance his knowledge along entomological lines he went to Harvard and took up some special work in entomology. Conditions were not favorable for the best work, and he relinquished his entomological studies, and, after casting about, decided to take up work in plant pathology under Dr. Volney Spaulding, of the University of Michigan. Largely through Dr. Spaulding's influence, Mr. Pierce became intensely interested in plant pathological studies. He developed into a keen observer and a thorough-going investigator.

In these early days there was comparatively little pathological work carried on in this country, and those engaged in it were few in number. The pathological work of the government had only just been inaugurated.

About 1887 or 1888 there appeared in California a serious grape disease, which spread rapidly and caused immense damage to the vine industry of that state. Early in 1889 the disease had become so virulent that the Section of Vegetable Pathology in the U. S. Department of Agriculture decided to undertake an investigation of the trouble. In casting about for someone to take up this work Professor Spaulding of Michigan was communicated with. He recommended Mr. Pierce, and Mr. Pierce was appointed. Mr. Pierce proceeded at once to Santa Ana, Calif., and made

that place his headquarters. He began at once a careful field study of the disease. After six or eight months of field studies he decided that he wanted to go abroad in order to get a line on the diseases of the grape in the south of France and in Italy. He went abroad at his own expense, and was away six or eight months. Upon his return he renewed his investigation of the grape diseases, and eight or nine months later published his valuable report on the California vine disease. Mr. Pierce continued grape investigations and took up other lines of work.

Gradually the laboratory at Santa Ana grew into one of the most important branches of the plant pathological work of the government. The name was changed to the Pacific Coast Laboratory, and Mr. Pierce was put in charge. He remained in charge of this work until December 31, 1906, when he resigned.

During Mr. Pierce's work on the Coast he conducted important investigations in the California vine disease, leaf curl of the peach, walnut blight, and the diseases of the grape.

Mr. Pierce was a man of quiet and unassuming habits. He was preeminently an investigator, and preferred to work alone. A careful study of the record of his accomplishments on the Pacific Coast will show that he was an indefatigable and earnest student.

B. T. GALLOWAY

Pathological greenhouse. On the basis of the presentation in PHYTOPATHOLOGY for February, 1916, of the need for controlled greenhouse conditions in botanical research (Potter, Alden A. The control of experimental conditions in phytopathological research, p. 81) funds have been secured for carrying out these ideas in connection with the investigations of the Bureau of Plant Industry on the cereal rusts, and it is hoped to have at least one unit of this apparatus in operation in Washington within the present year.

Cereal rust survey. An extensive barberry and cereal rust field survey is projected for the coming spring and summer by the Office of Cereal Investigations, Bureau of Plant Industry.

Personals. Dr. J. L. Weimer, formerly assistant in the Department of Botany of Purdue University, Lafayette, Indiana, has been appointed scientific assistant in the Bureau of Plant Industry, effective February 14, to take up work on the diseases of sweet potatoes and other truck crops.

Mr. Moses Levine, assistant in the Department of Botany and Plant Pathology, University of Minnesota, has recently been appointed assistant in Plant Pathology in the Kansas Agricultural College, Manhattan, Kan.

REPORT OF THE EIGHTH ANNUAL MEETING OF THE AMERICAN PHYTOPATHOLOGICAL SOCIETY

The eighth annual meeting of the Society was held in Barnard College, Columbia University, New York City, N. Y., December 27–30, 1916, in conjunction with the American Association for the Advancement of Science.

About ninety members were present and a program of eighty-three papers was presented, the abstracts of which appeared in the last number of PHYTOPATHOLOGY. Twenty-four new members were elected, making a total of three hundred and sixty-seven.

Joint sessions were held with Section G of the American Association for the Advancement of Science and also with the Botanical Society of America.

The following officers were elected:

President, Dr. Mel. T. Cook, Agricultural Experiment Station, New Brunswick, N. J.

Vice-President, Dr. Charles Brooks, U. S. Department of Agriculture, Washington, D. C.

Councilor for three years, Prof. H. S. Jackson, Purdue University Agricultural Experiment Station, Lafayette, Ind.

One of the Chief Editors of PHYTOPATHOLOGY *for three years*, Dr. G. P. Clinton, Agricultural Experiment Station, New Haven, Conn.

Associate Editors, J. B. Rorer, Port-of-Spain, Trinidad; Prof. H. P. Barss, Oregon Agricultural College, Corvallis, Ore.; Dr. Geo. M. Reed, University of Missouri, Columbia, Mo.; and Dr. H. A. Edson, U. S. Department of Agriculture, Washington, D. C.

The Society decided to hold its next annual meeting at Pittsburgh, Pa., in conjunction with the American Association for the Advancement of Science, December 28, 1917, to January 2, 1918.

AMENDMENT TO THE CONSTITUTION

Article II, Section 1, line 1, after the word "include" the word *sustaining* was inserted.

Article III, Section 3, line 1, after the word "become" *a sustaining life member by paying one hundred dollars in ten consecutive annual payments was substituted for* "a life member upon the payment of fifty dollars."

REPORTS OF COMMITTEES

The Committee on Common Names, consisting of F. C. Stewart, G. P. Clinton, F. L. Stevens, E. C. Stakman, and W. A. Orton, presented the following report and recommendations:

Carrying out the instructions of the Society at the Columbus meeting, the Committee sent copies of the partial list of common names which it had prepared to about 200 members of the Society for their criticisms. In consequence of the suggestions received the Committee has made some changes in the list and 30 names have been stricken from the list. The revised list contains the names of 17 host plants (alfalfa to cabbage) and 92 diseases. The adoption of this list is recommended.

The Committee recommends further that this work on common names be continued under the following plan:

(1) The American Phytopathological Society shall officially adopt a list of common names of plant diseases.

(2) There shall be a permanent standing committee of the Society, called the Committee on Common Names of Plant Diseases, consisting of five members, one member being elected by the Council each year to serve five years. The Committee shall elect its own officers. The members of the present Committee (1916) shall retire in the order of the length of service of each. A vacancy on this Committee shall be filled temporarily by appointment of the President of the Society, the appointee to serve until the next annual meeting, at which time the Council shall elect a member to complete the unfinished term.

(3) This Committee shall prepare and present to the Society for official action at the regular annual meeting a list of common names of plant diseases, and at each succeeding annual meeting a supplementary list of names may be presented. At least six weeks before the annual meeting the Committee shall submit a preliminary list of names to all members of the Society for suggestions and criticism in writing. At the beginning of the annual meeting the revised list shall be conspicuously posted to invite further suggestions and criticisms. The list as finally revised by the Committee shall be presented to the Society at the same annual meeting for final adoption. The list of names officially adopted at each annual meeting shall be printed in PHYTOPATHOLOGY in the report of the meeting of the Society. The official list may be amended under the same procedure.

Upon motion the report was accepted and the recommendations adopted. Later, in connection with a discussion of the proposed list of common names which the Committee had prepared, a motion to reconsider the action in regard to the report of the Committee was adopted, and a motion was made and carried that the Committee be instructed to submit to the entire membership of the Society by mail the list of common names which it approved and to request a vote for or against each name proposed, a three-fourths majority of the total membership being necessary for adoption of any name. A motion was also adopted authorizing the Committee on Common Names to change the above plans to make them accord with the above motion.

C. W. Edgerton was appointed on the Committee in place of G. P. Clinton, whose term expired. Since the close of the meeting F. C. Stewart and F. L. Stevens have resigned and the President has appointed in their places G. R. Lyman and J. B. S. Norton.

The Committee on Ways and Means, consisting of L. R. Jones, C. L. Shear, C. W. Edgerton, H. S. Jackson, and J. T. Barrett, did not report, the Chairman being absent.

The Committee on Bibliography, consisting of L. R. Jones, C. L. Shear, and R. A. Harper, made no formal report. C. L. Shear stated that the Committee had been unable, after two years' effort, to secure the fifty subscribers necessary for publication of the proposed card index to phytopathological literature. It had been the expectation of the Committee that a large proportion of the agricultural colleges and experiment stations would subscribe for the index, but only ten such subscriptions had been obtained. The informal report was accepted and the Committee discharged.

The Committee on the Schweinitz Collection of Fungi, consisting of C. L. Shear, J. C. Arthur, and A. G. Johnson, made a report of progress to the effect that the Curator of the Herbarium had offered to take whatever steps were feasible to accomplish the purpose desired by the Society. It is hoped to perfect the details and have the matter satisfactorily attended to during the present year.

The Committee on Institutional Standardization, consisting of H. S. Reed, H. H. Whetzel, and H. R. Fulton, presented no report and requested that it be discharged. The request was approved by the Society.

The Committee on Summer Meetings, consisting of Paul Murphy, E. C. Stakman, and Donald Reddick, presented no report, the Chairman being absent.

The Committee on Pure Culture Supply Laboratory, consisting of C. L. Shear, L. R. Jones, and G. P. Clinton, made a report of progress, and stated that an item had been introduced in the appropriation bill for the Bureau of Plant Industry for the next fiscal year to cover the inauguration of this work. Whatever is accomplished in this direction during the year will depend upon the fate of this appropriation.

TREASURER'S REPORT

Receipts:			
Balance from 1915		$655.64	
Dues of—			
268 regular members for 1916	$804.00		
72 sustaining life members	720.00		
9 members for 1915	27.00		
1 sustaining life member	100.00		
Overpayment 3 members	9.00	1,660.00	
Exchange from 8 members		1.22	
Interest		15.64	
Excess transfer from Society funds		5.00	$2,337.50
Expenditures:			
Appropriation to PHYTOPATHOLOGY 1915, and 1916		400.00	
Clerical work (inc. $14.80 for 1915)		73.43	
Printing abstracts, stationery, etc		185.07	
Secretary's traveling expenses to attend Columbus meeting		44.28	
Mimeograph work for F. C. Stewart		15.00	
Supplies		7.75	
Exchange on checks		.40	
Excess dues from 3 members		9.00	
Rebate for No. 1, Vol. V, exhausted		.50	
Sinking fund for PHYTOPATHOLOGY		501.58	
Telegrams		1.55	
Transfer to PHYTOPATHOLOGY acct. members		969.00	2,207.56
Balance			$129.94

FINANCIAL STATEMENT OF BUSINESS MANAGER OF PHYTOPATHOLOGY

Receipts:			
Balance from 1915		$47.91	
Advertising guarantee 1915		150.00	
Subscriptions and sales PHYTOPATHOLOGY		620.38	
Annual dues transferred account—			
9 members for 1915	$ 18.00		
268 regular members, 1916	536.00		
72 sustaining members (1 excess)	360.00		
1 sustaining member in full	50.00		
1 member who paid $10	5.00	969.00	

Sales PHYTOPATHOLOGY direct		18.10	
Neiberg subscription (sent to W. & W.)		3.25	
Extra illustrations in PHYTOPATHOLOGY, O'Gara and Hotson		11.28	
Annual appropriation from American Phytopathological Society for 1916		200.00	
Interest on deposits		.84	
Interest on mortgage, 6 months		15.00	$2,035.76
Expenditures:			
Cooke portrait		$26.00	
Separates from PHYTOPATHOLOGY		41.95	
Stationery, express, postage (Dr. Reddick)		35.00	
Phoenix files		.57	
Illustration of horse-chestnut		10.00	
Readjustment of dues one member paid to publishers		3.00	
Readjustment Neiberg subscription, paid to treasurer		3.25	
Insurance on stored stock		5.40	
Manufacture of PHYTOPATHOLOGY:			
No. 6, Vol. V, balance from 1915	$65.80		
No. 1, Vol. VI	432.82		
No. 2, Vol. VI	348.52		
No. 3, Vol. VI	338.78		
No. 4, Vol. VI	260.92		
No. 5, Vol. VI	165.82		
No. 6, Vol. VI, $147.30, pending	000.00	1,612.66	
Williams & Wilkins miscellaneous bills for postage, etc.		78.98	
Clerical work		70.43	
Reimbursement American Phytopathological Society account over-transfer		5.00	1,892.24
Balance			$143.52

These accounts were referred to an auditing committee, consisting of A. D. Selby, R. Kent Beattie, and E. C. Stakman. The Committee reported that they had examined the accounts and found them correct, and the reports were adopted.

RESOLUTIONS ADOPTED

A Committee, consisting of H. A. Edson, A. D. Selby, and John L. Sheldon, was appointed by the Society to draft resolutions in regard to the deaths of two members, W. A. Martin and Yungyen Young, and also of Professor T. J. Burrill. The following resolutions were presented:

"*Resolved*, That whereas in the death of W. A. Martin, of Houlton, Maine, and Yungyen Young, of Shanghai, China, the American Phytopathological Society has been deprived of two of its members, the Society records its sincere regret at the taking of these gentlemen.

"That whereas in the death of Professor T. J. Burrill, of the University of Illinois, who first demonstrated the existence of bacterial diseases of plants, there has been removed an eminent leader in botanical and phytopathological research, the American Phytopathological Society expresses its sincere regret at the departure of this eminent scholar and teacher, and records its appreciation of the service rendered our science by his researches.

"That these resolutions be filed with the records of the Society and printed in PHYTOPATHOLOGY."

The following resolution was also passed by the Society:

"*Resolved*, That the Society express its deep appreciation and gratitude to the local Committee and the members of the Department of Botany of Columbia University for the excellent facilities provided and for the many courtesies extended during the meeting.

MISCELLANEOUS BUSINESS

Upon motion the Society voted to appropriate two hundred dollars from any available funds for use in the support of PHYTOPATHOLOGY for 1917.

In response to a request from the Botanical Society of America to nominate a member of the American Phytopathological Society for the editorial board of the Botanical Society, Dr. A. G. Johnson was recommended by the Council. The Society approved of the action of the Council.

The Board of Editors made the following recommendations in regard to PHYTOPATHOLOGY, and these were approved by the Council:

(1) That no article be accepted which is written in simplified spelling, but that in the case of words which have two or more forms in good usage strict uniformity is not required, but the shorter and simpler forms are to be preferred.

(2) That PHYTOPATHOLOGY be issued monthly and include five hundred or more pages during the year, the price of the JOURNAL to members, including dues, to be four dollars and to subscribers five dollars per year, the increase in price to begin January 1, 1918.

(3) Space of one-half page or more at the end of long articles is to be used for the publication of briefer articles or notes in order to avoid wasting space.

(4) It is recommended to members of the Society that they refrain from publishing original matter in extension publications, weekly news letters, and other similar publications which are not usually preserved and permanently filed, also that such references be omitted from the list of literature.

(5) Recommended that authors of phytopathological papers which are published in proceedings of academies, horticultural societies, and other publications of limited distribution, prepare abstracts covering the original matter for publication in PHYTOPATHOLOGY.

Professor J. B. S. Norton presented a plan for "a standard chart for per cent estimates" in regard to injury and conditions of diseased plants. Upon motion this plan was referred to a Committee, consisting of L. R. Jones, V. B. Stewart, and H. B. Humphrey, for consideration and report to the Society at its next meeting.

Dr. E. W. Allen, Editor of the Experiment Station Record, in response to the resolution adopted by the Society at its last meeting requesting that titles of papers abstracted in the Record be published in full in the original language, stated that after full consideration of the matter it did not appear practicable to adopt the proposed change.

Dr. Donald Reddick, Editor of PHYTOPATHOLOGY, presented a verbal report calling attention to some of the matters discussed by the Board as reported above.

Upon motion the Society directed the Secretary to publish during the year a new membership list.

The Secretary called attention to the need of prompt notice of change of address of members, in order to avoid inconvenience and loss of copies of the JOURNAL, and unnecessary expense in correspondence.

C. L. SHEAR,
Secretary-Treasurer

REPORT OF MEETING OF THE PACIFIC DIVISION OF THE AMERICAN PHYTOPATHOLOGICAL SOCIETY

A meeting of the Pacific Division was held at the University of California, Berkeley, December 28 and 29, 1916. President J. T. Barrett, of the Citrus Experiment Station, Riverside, California, presided at the sessions, while Ralph E. Smith, of Berkeley, California, acted as secretary in the absence of W. T. Horne, of Berkeley who is spending a leave of absence in Cuba. At the business session of the Society the following officers were elected for the coming year:

President, H. P. Barss, Corvallis, Oregon.

Vice President, James McMurphy, Leland Stanford Junior University, Palo Alto, California.

Secretary-Treasurer, W. T. Horne, Berkeley, California.

The following papers were presented:

Apple rosette. M. A. Willis

No abstract.

An Alternaria blight of tomatoes in California. Bruce Douglas

No abstract.

Sour rot of lemons. Clayton O. Smith

No abstract.

Stem-end decay of Valencia oranges in transit. Clayton O. Smith

No abstract.

Some effects of sulphur on soils. H. S. Reed

Sulphur in the form of elemental sulphur, sulphides, or sulphates is widely used as a fungicide. Much of this material finds its way eventually into the soil. Its effect as a soil constituent is therefore pertinent.

Under anaerobic conditions microorganisms may reduce sulphates to sulphites or sulphides, both of which are toxic to vegetation. Oxidation processes may convert sulphides and elemental sulphur to sulphates. The process is largely, if not entirely, due to biological agencies. If the oxidation process is incomplete sulphites may be formed.

The harmful effects of sulphur are more common in soil deficient in organic matter, or in soils having an acid reaction.

Black-heart disease of the apricot. Helen Czarnecki

Studies on Monilia. Edith Phillips

No abstract.

Miscellaneous observations. James McMurphy

No abstract.

The experimental investigation of alleged smelter smoke injury in Calaveras County, California. W. W. Thomas

No abstract.

Pythiacystis related to Phytophthora. J. T. Barrett

For some time three strains, perhaps distinct species, of a fungus, whose asexual stages resemble very closely those of *Pythiacystis citrophthora* Smith & Smith, have been under observation. These strains differ mainly from the latter fungus in that

they produce in culture oospores while the perfect stage has not yet been reported from any culture of *P. citrophthora* isolated from any variety or species of Citrus.

Of the three strains mentioned, one was isolated from decaying apples in March 1908 in Illinois; one from bark of a young apricot tree in March 1916 in California and the third from bark of an avocado tree by H. S. Fawcett in May 1914.

A comparison of the three forms with four species of Phytophthora has revealed a very close similarity of the oogonia, oospores, and antheridia to those of *P. cactorum* (Cohn & Leb.) Schroeter, while their asexual spores, (sporangia and conidia) differ mainly in the manner of separating from the hyphae.

This marked similarity of their sexual organs to those of *P. cactorum*, and of their sporangia to those of *Pythiacystis citrophthora* would seem to indicate a close relationship of the two genera Pythiacystis and Phytophthora.

Variations in Colletotrichum glœosporioides. O. F. BURGER

Cultures of *Colletotrichum glœosporioides* were isolated from different *Citrus* species in California. They have been grown on six different media and each strain responds differently to the media. The size of the spore, depends in part upon the medium used. A hundred spores of each strain were measured and it was found that the mean spore-length of most of the strains, when grown on green bean pods, is 15 microns. Other strains were found, however, which have a mean spore-length of 12 and 17 microns respectively.

The cultures can be classified according to their mycelial characters, when grown on artificial media. Class A. Mycelium dark, olive color, giving a fluffy growth with but scant spore production. Class B. Mycelium dark, appressed but abundant spore production. Class C. White mycelium and abundant spore production.

Sexuality in Cunninghamella. O. F. BURGER

Pure cultures were made from single spore heads of *Cunninghamella bertholletiæ* and during the entire work no zygospores were formed in the culture tubes. But when two strains, whose gametes were compatible are contrasted in an agar plate zygospores are produced at a point where the cultures meet.

A sexual reaction did not occur with Blakeslee's Mucor V, plus and minus, or his plus and minus strains of *Cunninghamella echinulata*. The strains of *C. bertholletiae* which acted as neutrals with these two fungi formed normal zygospores when contrasted among themselves.

The peculiarity in their method of conjugation is, that there were marked differences in their ability to conjugate with certain strains. Strain *A* will conjugate with strains *B* and *C* and strains *B* and *C* will also conjugate and form normal zygospores. *Cunninghamella bertholletiæ* is therefore a pseudo-heterothallic mucor.

Curly top of the sugar beet. RALPH E. SMITH

No abstract.

One session was devoted to a discussion of the so-called non-parasitic or physiological plant diseases, attention being paid to a number of obscure troubles which are of particular importance in the Far West. A discussion also took place concerning possible means of making the Society more useful and securing a representative attendance from the different states at its meetings. The acting secretary was instructed to take up the latter subject with members in the territory covered by the Division to see what can be done along this line.

W. T. HORNE,
Secretary-Treasurer

LITERATURE ON AMERICAN PLANT DISEASES[1]

COMPILED BY EUNICE R. OBERLY, LIBRARIAN, BUREAU OF PLANT INDUSTRY AND FLORENCE P. SMITH, ASSISTANT

December, 1916, to January, 1917

Alaska Agricultural Experiment Stations. Plant diseases. Alaska Agr. Expt. Stas. Rpt. **1915**: 39–41. 1916.

Allard, Harry Ardell. A specific mosaic disease in Nicotiana viscosum distinct from the mosaic disease of tobacco. Jour. Agr. Research **7,** no. 11: 481–486, pl. 35. December 11, 1916.

Averna Saccá, Rosario. Molestias cryptogamicas do caféeiro. Bol. Agr. [São Paulo] **17,** no. 10: 790–840, fig. 157–285. Outubro, 1916.

Baker, Carl Fuller. Additional notes on Philippine plant diseases. Phil. Agr. and Forester **5,** no. 3: 73–78. July, 1916.

Bancroft, C. Keith. Report on the South American leaf disease of the Para rubber tree. Jour. Bd. Agr. Brit. Guiana **10,** no. 1: 13–33. October, 1916.

Fusicladium macrosporum; die back.

Boyce, J. S. Pycnia of Cronartium pyriforme. Phytopathology **6,** no. 6: 446–447. December, 1916.

On *Pinus ponderosa.*

Brandes, E. W. Report of the plant pathologist. Porto Rico Agr. Expt. Sta. Rpt. **1915**: 34–35. 1916.

Experiments in the control of a banana disease; miscellaneous experiments.

Brooks, Charles, and **Cooley, Jacquelin Smith.** Temperature relations of apple-rot fungi. Jour. Agr. Research **8,** no. 4: 139–164, 25 fig., 3 pl. January 22, 1917.

Chivers, Arthur Houston. An epidemic of rust on mint. Mycologia **9,** no. 1: 41–42. January, 1917.

Puccinia Menthæ Pers.

Cook, Melville Thurston, and **Wilson, Guy West.** The influence of the tannin content of the host plant on Endothia parasitica and related species. New Jersey Agr. Expt. Sta. Bul. 291, 47 p. 1916.

Shorter article with same title published in Bot. Gaz., November, 1915. Noted in previous list.

Dodge, Bernard Ogilvie, and **Adams, James Fowler.** Notes relating to the Gymnosporangia on Myrica and Comptonia. Mycologia **9,** no. 1: 23–29, 1 fig., 3 pl. January, 1917.

[1] This list aims to include the publications of North and South America, the West India Islands, and islands controlled by the United States, and articles by American writers appearing in foreign journals. All authors are urged to coöperate in making the list complete by sending their separates and by making corrections and additions, and especially by calling attention to meritorious articles published outside of regular journals. Reprints or correspondence should be addressed to Miss E. R. Oberly, Librarian, Bureau of Plant Industry, U. S. Dept. Agric., Washington, D. C.

Elliott, John A. The sweet potato "soil rot" or "pox" organism. Science n. s. **44,** no. 1142: 709–710. November 17, 1916.

Cystospora batata gen. nov., sp. nov.

Fawcett, George L. A Porto Rican disease of bananas. Porto Rico Agr. Expt. Sta. Rpt. **1915:** 36–41. 1916.

Closely resembles Panama disease.

Fawcett, Howard S. Citrus scab. Phytopathology **6,** no. 6: 442–445. December, 1916.

Discussion of article by Grossenbacher.

——— A Pythiacystis on avocado trees. Phytopathology **6,** no. 6: 433–435. December, 1916.

Fromme, Fred Denton, and **Thomas, H. E.** The root-rot disease of the apple in Virginia. Science n. s. **45,** no. 1152: 93. January 26, 1917.

Xylaria sp.

Germano de Souza, Raul. O Tylenchus acuto-acudatus (?) nos cafezaes de Indaiatuba. Bol. Agr. [São Paulo] **17,** no. 9: 726–736, 7 fig. Setembro, 1916.

Gile, Philip Lindsey. Chlorosis of pineapples induced by manganese and carbonate of lime. Science n. s. **44,** no. 1146: 855–857. December 15, 1916.

Güssow, Hans Theodor. Canada's white pine possessions are threatened with extermination. An authoritative discussion of white pine blister rust. Canad. Forestry Jour. **13,** no. 1: 900–906, illus. January, 1917.

——— Leaf roll in tomatoes? Phytopathology **6,** no. 6: 447. December, 1916.

Hartley, Carl, and **Pierce, Roy Gifford.** The control of damping-off of coniferous seedlings. U. S. Dept. Agr. Bul. 453, 32 p., 1 fig., 2 pl. 1917.

Pythium debaryanum; Fusarium moniliforme; Corticium vagum var. Solani.

Heald, Frederick De Forest. Some new facts concerning wheat smut. Proc. Washington State Grain Growers, Shippers and Millers Assoc. 10th Ann. Meeting, **1916:** 38–45, 2 fig. 1916.

Huard, Victor Amédée. Les principales espèces d'insectes nuisibles et de maladies végétales. [Quebec Dept. Agr.] Bul. 23, 75 p., 78 fig. 1916.

Hubert, Ernest E. Celluloid cylinders for inoculation chambers. Phytopathology **6,** no. 6: 447–450, 1 fig. December, 1916.

Jehle, Robert Andrew. Means of identifying citrus canker. Quart. Bul. State Plant Bd. Florida **1,** no. 1: 2–10, 12 pl. (partly col.). October, 1916.

Johnson, James. Enfermedades del tabaco y manera de combatirlas. Parte V. Hacienda **12,** no. 4: 124–126, illus. Enero, 1917.

Johnston, John Robert. Enfermedad de la raiz de la caña de azúcar. Hacienda **12,** no. 4: 117–118, illus. Enero, 1917.

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Comparison of *M. stenophyllus* and *M. sacchari.*

Lewis, A. C. Cotton wilt in Georgia. Georgia State Bd. Ent. Bul. 40, 18 p., 8 pl. 1915.

Varieties of wilt resistant cotton, p. 8 ff.

McClintock, James A. Is cucumber mosaic carried by seed? Science n. s. **44,** no. 1144: 786–787. December 1, 1916.

——— Peanut mosaic. Science n. s. **45,** no. 1150: 47–48. January 12, 1917.

——— Sclerotinia libertiana on snap beans. Phytopathology **6,** no. 6: 436–441, 2 fig. December, 1916.

McCubbin, W. A. The white pine blister rust: does the fungus winter on the currant? Science n. s. **45,** no. 1152: 87. January 26, 1917.

Martin, William H. Influence of Bordeaux mixture on the rates of transpiration from abscised leaves and from potted plants. Jour. Agr. Research **7,** no 12: 529–548. December 18, 1916.
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Massey, L. M. The hard rot disease of gladiolus. New York Cornell Agr. Expt. Sta. Bul. 380: 149–181, fig. 38–44, pl. 15–16. 1916.
Bibliography, p. 180–181.
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Mendiola, Nemesio, and **Espino, Rafael B.** Some phycomycetous diseases of cultivated plants in the Philippines. Phil. Agr. and Forester. **5,** no. 3: 66–71, illus. July, 1916.
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Phytophthora diseases; *Pythium Debaryanum.*

Mix, A. J. Cork, drouth spot and related diseases of the apple. New York State Agr. Expt. Sta. Bul. 426: 473–522, 12 pl. 1916.
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——— Sun-scald of fruit trees, a type of winter injury. New York Cornell Agr. Expt. Sta. Bul. 382: 233–284, fig. 60–61, pl. 18–19. 1916.
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Morse, Warner Jackson. Studies upon the blackleg disease of the potato, with special reference to the relationship of the causal organisms. Jour. Agr. Research **8,** no. 3: 79–126. January 15, 1917.
Literature cited, p. 124–126.
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Nowell, William. Fungoid and bacterial diseases. West Indian Bul. **15,** no. 2: 133–143, 146–147. 1915.
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——— Rosellinia root diseases in the Lesser Antilles. West Indian Bul. **16,** no. 1: 31–71, 12 fig. on 4 pl. 1916.
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Seaver, Fred Jay. Some papers presented during convocation week. Mycologia **9,** no. 1: 42–46. January, 1917.
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Smith, Erwin Frink. Mechanism of tumor growth in crowngall. Jour. Agr. Research **8,** no. 5: 165–186, pl. 4–65. January 29, 1917.
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[PHYTOPATHOLOGY, for February, 1917 (**7:** 1–81, Pl. I) was issued February 7, 1917.]